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An Empirical Method to Derive Hourly Temperature Frequencies for Locations Possessing Only Summarized Climate Information

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Prior research on the subject of surface air temperature is abundant in professional literature, however little attention has been paid to examining the frequency of occurrence of this parameter. A number of professional fields, such as equipment and building design, agriculture, and the military, have performed research in this area as they require knowledge of how often certain temperature thresholds are equaled or exceeded. Prior research focused on both estimating temperature frequencies at any point along the cumulative temperature frequency curve, and on estimation at fixed frequency points within the tails of the distribution. Using linear discriminant analysis with selected topographic and climatic variables, a model has been developed that assigns stations to discriminant function groups on a monthly basis that reflects commonality in their temperature frequency distributions. Discriminant functions and curve-fitting equations were generated. The model performed best for locations with low to moderate elevations; in regions with higher station densities; and during the warmer months of the year. Reduced performance correlated well with locations at high elevations; at high latitudes; in regions of lower station density; and during the colder months of the year.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

PREFACE*

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The work was performed by Dr. Paul F. Krause during the period October 1994 to December 1995 under the supervision of Mr. Kevin R. Slocum, Team Leader; Ms. Betty Mandel, Chief of the Environmental Sciences Division; Mr. Joseph E. Swistak, Director of the Topographic Technology Laboratory; and Dr. Richard B. Gomez, Associate Directory, Technology Directorate.

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EXECUTIVE SUMMARY

Climatic information has a wide variety of important military applications. As examples, these data are used: in equipment design; for planning purposes and Tactical Decision Aid (TDA) development; as inputs to performance models; and, to generate realistic environmental scenarios for modeling and simulation activities. Two primary problems arise when working with any climatic data -- station density and the comprehensiveness of the available data. These factors impact both the use of the data and the assumptions that can be made regarding the representativeness of the data when extrapolated to a particular location or area. The first factor, station density, is a problem especially in areas outside the continental United States (OCONUS). Very often, a military user must characterize the climate at a particular site for which no climate recording stations exist. The degree of relatedness between the environment (topographic and climatic) of the particular site and that of adjacent, available climate station locations may render any climatic extrapolations nothing more than best guesses.

This research is directed toward the second factor, i.e., the characteristics of available climate data. These characteristics can severely limit the data's utility. In most instances, available climate information for the vast majority of stations in the world consist of summarized data in the form of monthly means and extremes. These values represent average conditions as well as provide a likely envelope of conditions that can be expected to be encountered at a particular location during any particular month. These types of data, however, do not provide the user with an indication of 'how often' certain conditions are equaled or exceeded.

This research report focuses on surface air temperature. Methods to determine the frequency of occurrence of air temperature commenced during the late 1940s. The military as well as the building design and heating and air conditioning communities were at the forefront of research on this topic. Their past research focused both on the entire temperature frequency curve and also on fixed frequency points in the tails of the distribution (e.g., 1-, 5-, and 10-percentile levels). The developed model in this report uses common geographic and climatic variables indicated as important by these earlier researchers to assign stations to groups where group members have statistically similar temperature frequency curves. Developed equations then permit a user to determine the frequency of occurrence of any input temperature. This technique should enhance the capability of military planners to better assess the nature of the thermal environment as well as estimate the percentage of time that the thermal environment could possibly impact their equipment, personnel and planned military operations.

AN EMPIRICAL METHOD TO DERIVE HOURLY TEMPERATURE FREQUENCIES FOR LOCATIONS POSSESSING ONLY SUMMARIZED DATA

INTRODUCTION

Temperature frequency information has a wide variety of important uses and applications. Knowing how often various temperatures are equaled or exceeded a specific percentage of time has important applications in: building design and construction (Nicodemus and Guttman, 1980; Doesken and McKee, 1983; Boyd, 1985; Kunkel, 1986; Farago and Katz, 1990); assessing heating and cooling requirements (Crow, 1963; Ecodyne, 1980; ASHRAE, 1981, 1989); agriculture (Bootsma, 1976; Linvill, 1990); animal production (Griffiths and Driscoll, 1982); estimating the frequency of heat and cold stress on persons (Lackey, 1964; Oliver, 1973); equipment design (Meigs, 1953; Sissenwine and Cormier, 1974; Tattelman and Kantor, 1977; Krause, 1980); assessing the life expectancy of perishable items (Court, 1952); examining the thermal environments of various types of stored materiel and explosives (Krause, 1978); and, assessing potential impacts on military activities (Spreen and Manos, 1952; Boselly and Churchill, 1992).

Unfortunately, hourly temperature data are not available for every desired location in the world. In the United States (U.S.), for example, around 300 stations (normally termed "first-order" stations) routinely take hourly temperature measurements (Karl and Quayle, 1988). This represents about 1 station for every 12,000 mi^2. A denser network of U.S. cooperative stations, totaling roughly 8,300 (Jacks, 1993), provides temperature measurements, but only in the form of daily summarized data (Karl and Quayle, 1988). As an example of this denser network, Figure 1 shows first-order and cooperative stations for the Northeast U.S. (Northeast Regional Climate Center, 1995).[1] This region contains 35 first-order stations and nearly 900 cooperative stations.

Performing temperature frequency analysis for this region with only the 35 first-order stations provides a density of 1 station for roughly 6,810 mi^2. If temperature frequencies could be generated for the additional 900 cooperative stations, then the density would increase to approximately 1 station for every 255 mi^2. Foreign stations present another problem, inasmuch as available data for most non-U.S. locations generally consist of only monthly summarized statistics for selected major cities.

[1] From "Climate Data Bases" by Northeast Regional Climate Center at Cornell University, 1995, World Wide Web (http://met-www.cit.cornell.edu/nrcc_database.html). Adapted with permission.

Therefore, when the question arises as to how often certain temperatures occur at a particular location, it is quite often impossible, based on the availability of hourly data and characteristics of the available summarized temperature data, to estimate this frequency of occurrence with any degree of accuracy and confidence. As an example,

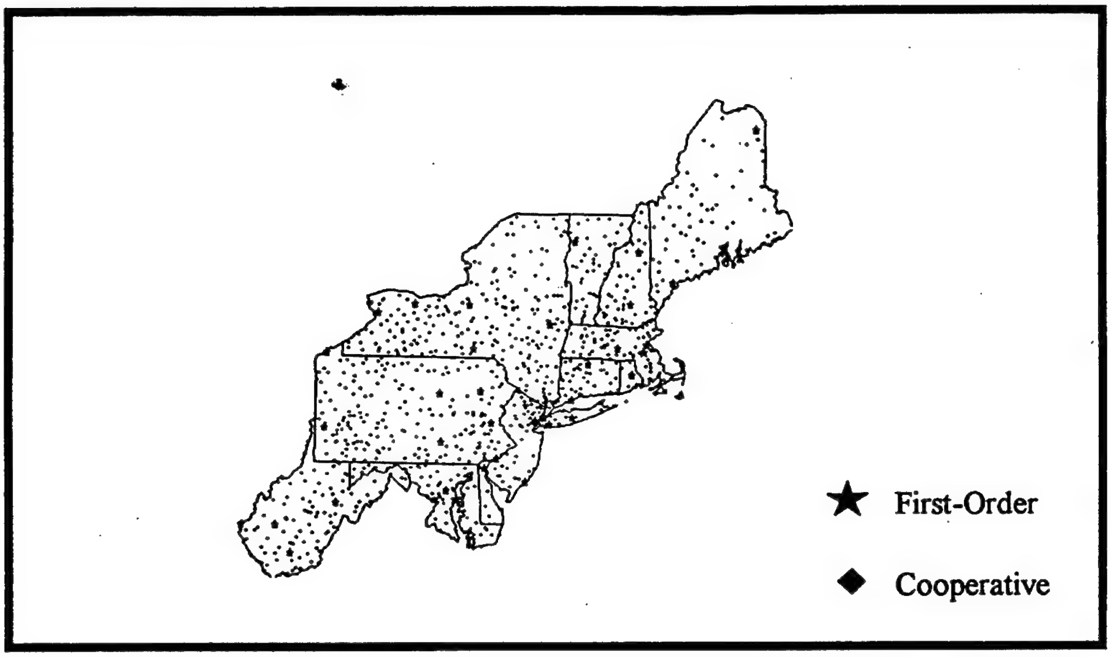

Figure 1. Map of Locations of First-Order and Cooperative Stations in the Northeast (Northeast Regional Climate Center, 1995)

Table 1 shows the monthly summary temperature statistics for Los Angeles, CA, for September (Naval Oceanographic Command Detachment (NOCD), 1992). If the question

Table 1. September Summary Temperature Statistics for Los Angeles, CA

Absolute Maximum Temperature	110°F
Mean Daily Maximum Temperature	76°F
Average Monthly Temperature	70°F
Mean Daily Minimum Temperature	63°F
Absolute Minimum Temperature	47°F

arose as to how often during September that temperatures exceeded 80°F, these summary statistics would be of little use. Figure 2 shows that 80°F is exceeded, on the average, only about 4 percent of the time. The temperature frequency curve has an extremely high positive skew. Available summary monthly statistics do not provide sufficient information to derive this frequency of occurrence with any degree of accuracy.

Past research into estimating the frequency of occurrence of temperatures from summarized information has taken a number of different paths These results indicate that, as a rule, locations with common topographic and climatic attributes possess comparable

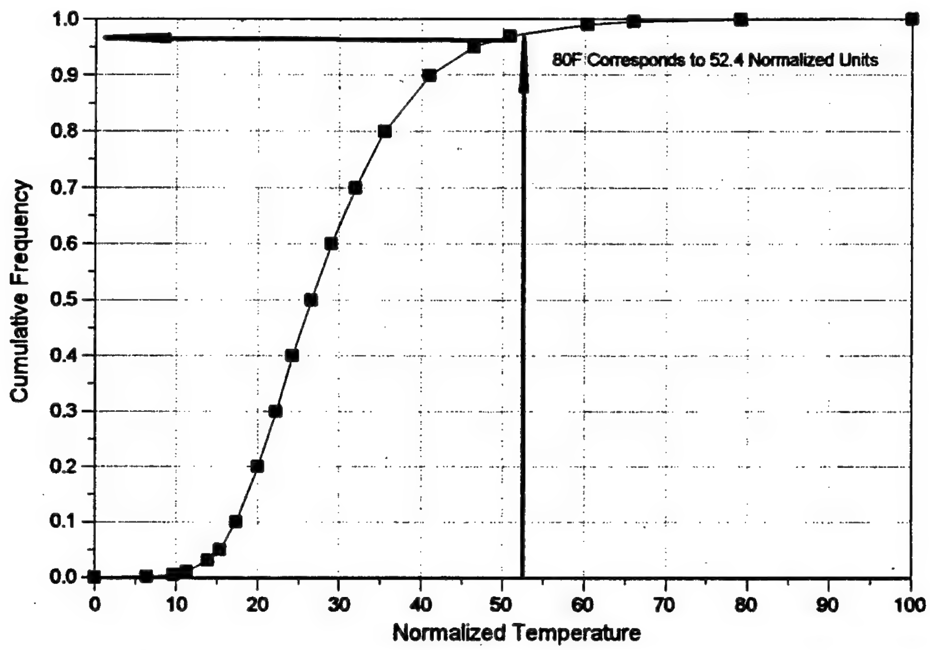

Figure. 2 Cumulative Temperature Frequency Curve for September: Los Angeles, CA

temperature frequency distributions. The goal of this research is to develop a technique to permit the estimation of monthly temperature frequencies at any location for which these topographic and climatic variables exist. To achieve this goal, past research efforts were examined to uncover previous approaches to this problem and to ascertain the topographic and climatic commonalties for locations possessing similar temperature frequency distributions.

AN EXAMINATION OF PRIOR INVESTIGATIONS

Research into the generation of temperature frequencies from summarized data has encompassed a variety of approaches. The necessity of this research was best summed up by Court (1951, p. 378) when he stated that "...[frequency distributions] are, however, more significant for most purposes, since they indicate the likelihood of occurrence of actual temperatures whose identity is lost in the computation of daily means."

Over the years, research varied from several attempts at developing methods to reconstruct the entire temperature frequency distribution to the analysis of smaller segments (most notably the tails) of the temperature frequency distribution curve. However, research on this topic has been less than prolific and has been primarily generated by the building design, heating and air conditioning, and military research communities. Discussions of frequency distributions in climatological texts have primarily focused on elements other than temperature. A cursory examination of several climatology methods texts (Conrad and Pollack, 1950; Stringer, 1972; and Oliver, 1973) has shown a primary focus on climatic elements other than temperature. Essenwanger's definitive work on atmospheric statistics (1976) all but ignores temperature and its distributional characteristics. Likewise, Linacre's reference guide on climatology (1992) devotes a chapter each to the discussion of the distributional characteristics of solar radiation, wind and precipitation, while omitting any detailed mention of temperature. The following chronology outlines the methods, techniques and direction past research has taken in this regard.

Graphical Depiction

Maps were the primary vehicle used in the earliest published studies to portray the spatial distribution of temperature frequencies. Using data summaries generated in 1944 by the U.S. Weather Bureau, such parameters as normal daily temperature range (difference between the mean daily maximum and mean daily minimum) and the frequency of occurrence of well-known critical thresholds, such as 32°F, 0°F, etc., were computed and published for the continental U.S. (CONUS) (Visher, 1946, 1954). The procedures and methodologies used in isotherm construction, interpolation and extrapolation techniques, and the identification of the data source stations are, unfortunately, an unknown. In addition, the maps did not show frequencies of temperatures in the tails of the distribution -- a fact that limits the use of these products in the design arena. The method, however, provided a mechanism by which the distribution of different treatments of temperature could be analyzed spatially and broad geographic patterns could be ascertained.

Graphical Depiction and Statistical Groupings

Court (1951) investigated the generation of temperature frequencies for places where only average monthly temperatures are available. At the time that Court's article was written, one monumental difficulty was the paucity of summarized cumulative frequency tabulations available to the researcher. Another adversity was the intensive manual effort required to extract, manipulate and statistically process the large volumes of required data. Court (1951, p. 379) remarked that "So gigantic the mass of data...that a major difficulty was the selection, the setting of limits, and the determination of the point of attack."

Only one set of appropriate temperature frequency tabulations could be uncovered by Court -- the set was developed by the U.S. Weather Bureau and the Works Progress Administration. From these data, consisting of temperature frequencies for 117 U.S. stations for a 5-year period-of-record, Court pared away roughly two-thirds of the stations to arrive at a manageable number (40) and still maintain a fairly uniform geographic coverage. January and July were selected as the months for consideration. Frequency distributions of January and July hourly temperatures were then graphed and measures such as standard deviation, skewness and kurtosis also were computed.

Based on similarities of the statistical measures and the morphology of the temperature curves, Court divided CONUS into three primary temperature frequency regions (Figure 3)[2]. Although no attempt was made by Court to approximate the actual frequencies of temperatures at various statistical levels, the study has important implications in that it graphically and statistically demonstrates the similarities of monthly temperature frequency distributions within fairly homogeneous geographic regions.

Statistical Grouping: The Entire Temperature Frequency Curve

Several years after Court's article appeared, the U.S. Army Quartermaster Research and Development Center let a contract with the Weather Corporation of America and Weathercasts Inc. to develop a methodology to enable the prediction of temperature, precipitation and dew point frequencies (Clark, 1954). Although the contract was never completed and formally published, a series of progress reports survive

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[2] From "Temperature Frequencies in the United States" by A. Court, 1951, Journal of Meteorology, 8, p. 380. Reprinted by permission.

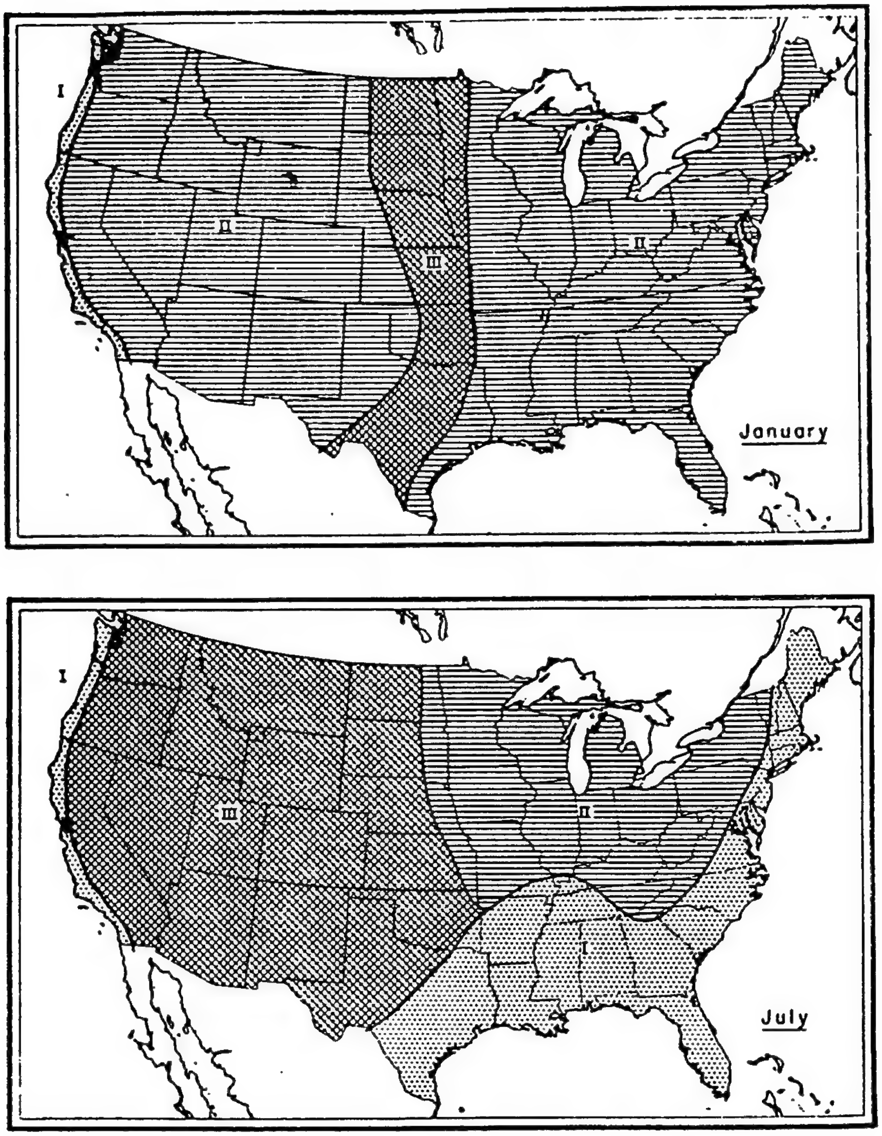

Figure. 3 Temperature Frequency Regions for January and July (Court, 1951)

that outline the methodologies used, rationale for using the techniques, and a cursory overview of some of the preliminary results.

With regard to temperature, Clark selected January as the month for an initial proof-of-principle study. The proposed methodology involved computing monthly means, standard deviations, and measures of skewness and kurtosis for a 5-year data set of 72 stations in CONUS. This closely mirrored the work of Court (1951). Temperature data were then computed at 11 standard levels along the cumulative frequency curve (5, 10, 20, 30, 40, 50, 60, 70, 80, 90 and 95) and converted into their standardized 't-variate' equivalent (more commonly referred to as 'Z-scores') using the formula

$$\text{t-variate} = (t_i - t_m)/sd \qquad (1)$$

where t_i is the temperature at each level, t_m is the mean monthly temperature and sd is the standard deviation of the monthly air temperature. Simple correlation of the stations' means, standard deviations, and measures of skewness and kurtosis was then used to assign the stations into groups. Once in groups, a standard or average curve representing the entire group was generated from the 't-variate' curves of the group members.

Sixteen (16) groups or "Temperature Frequency Types" were created for CONUS. The "Types" were: Great Basin, Central Plains, Lee of Great Lakes, Indiana-Ohio, Mountain, Central Atlantic Coast, South Atlantic, Central Pacific Coast, Interior Valleys (East Coast), North Pacific, Gulf Coast, Florida Peninsula, Great Valley, Southern, Los Angeles Basin and Northern Plains. Another category, "Unclassified", contained the stations that did not fit into any of the above groups. Since the source documents for these findings are progress reports and not part of a more detailed final report, no indication of goodness-of-fit of the individual station curves with the group standard curves appears in these documents, although Clark implies that a reasonable fit was attained.

Clark (1954) does stress that a denser network of stations is required to fill in the gaps (transition zones) between these generated "Types" and that additional types will inevitably have to be generated to account for those stations categorized as "Unclassified". Based on the geographic and climatic locations of the groups, Clark makes the following conclusions: 1) areas with the same general circulation patterns will have the same general transformed temperature frequency curves; 2) major topographic features exert enough influence on the general circulation to influence the temperature distribution in their vicinity; and, 3) much of the diversity in the temperature climate of the U.S. is the result of local influences principally due to topography. No further mention of this study appears in any of the subsequent literature that was reviewed. The results from Clark's preliminary progress reports, however, demonstrate a linkage of the characteristics of a

station's temperature frequency distribution with air mass and topographic factors.

Estimating Frequencies of High Temperatures

Meigs (1953) used data from 31 U.S. and 26 foreign stations in an effort to demonstrate the relationship between the mean daily maximum temperature and the frequency of occurrence of temperatures above 110°F, 115°F and 120°F. Based on data from these 57 stations, a set of curves was developed that required input of the mean daily maximum temperature to approximate the percentage of days per month that these aforementioned temperature levels would be equaled or exceeded. As to the accuracy of this method, Meigs states that it "...has a reasonably satisfactory validity except in monsoon and some tropical areas" (Meigs, 1953, p. 3). No further elaboration on the developed model is provided. Actual temperature frequency data from six hot desert stations are presented in the report. They graphically show a fairly good fit to the curves. However, neither 'goodness-of-fit' statistics are provided nor discussions of the weaknesses of the developed curves in other than hot desert locations.

Almost 20 years later, Williams (1972) conducted a similar study to develop a base from which inferences could be drawn concerning the relationship between high temperature and elevation. Using stations from the Southwest U.S. with a 20-year period-of-record, Williams plotted the 1-, 5-, and 10-percentile high temperatures for the

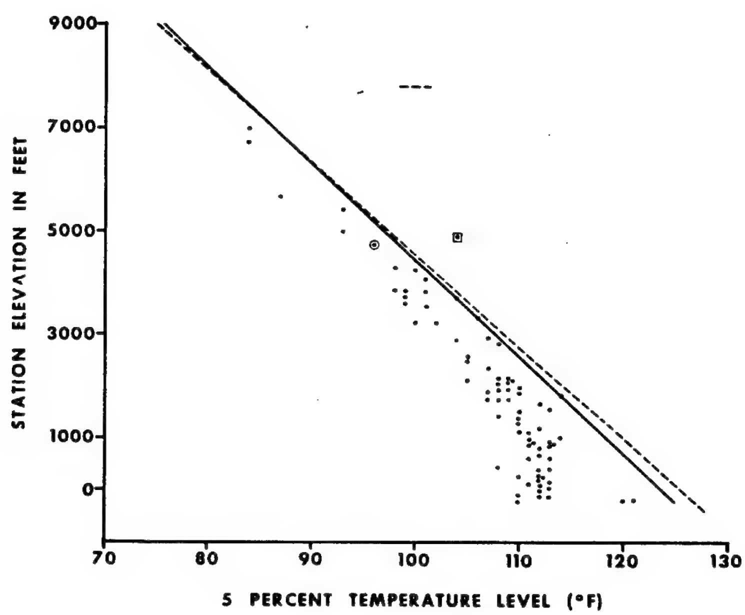

Figure. 4 Five-Percent Temperature Level for Hottest Four Months in the Southwest U.S. (Williams, 1972)

hottest month and for the hottest four months versus elevation. Williams' results indicated that below elevations of about 1,500 to 2,000 feet, little relationship appears to exist. At higher elevations, however, the relationship followed the dry adiabatic lapse rate quite closely (Figure 4). He then developed a series of histograms that showed the difference between each of these frequency levels and the absolute maximum temperature, and the mean monthly maximum and mean daily maximum temperatures. Figure 5 shows the

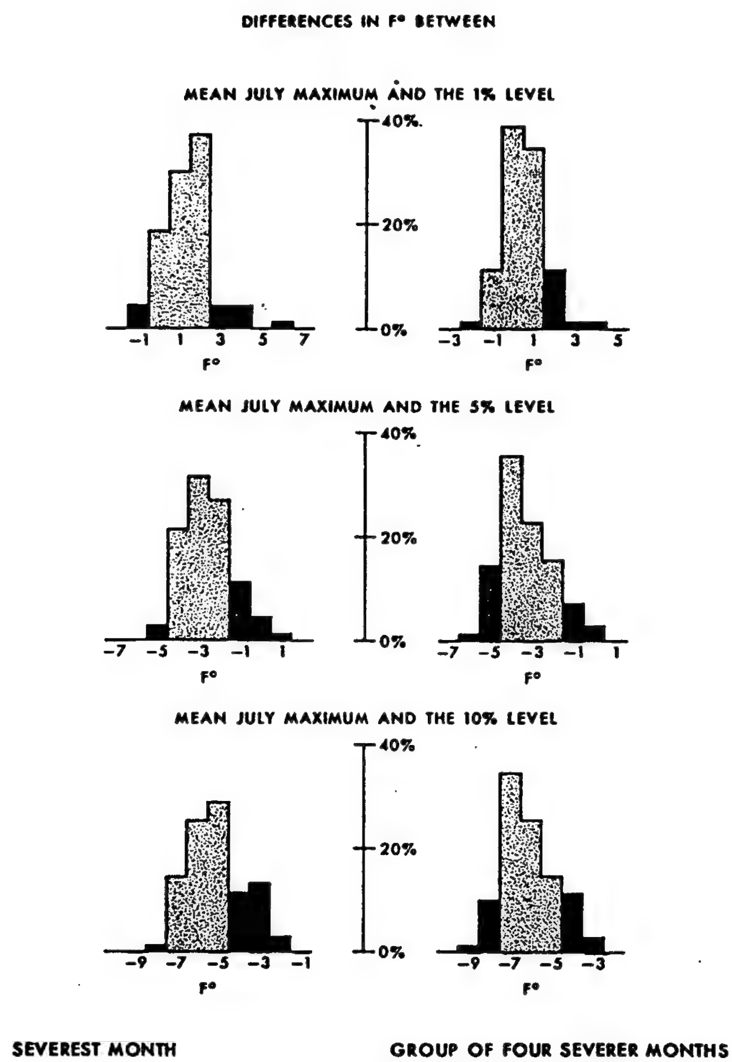

Figure. 5 Differences Between the Mean July Maximum and the 1-, 5-, and 10-Percentile High Temperatures (Williams, 1972)

differences between the mean July maximum temperature and the 1-, 5-, and 10-percentile temperature levels. Unfortunately, Williams does not provide a detailed discussion of the distribution of the differences and the characteristics of stations used in the study and their locations within the histograms themselves.

Non-Statistical Estimation: The Entire Temperature Frequency Curve

In the mid-1950s, research began on a graphical method that would provide the capability to predict temperature frequencies at all points along the cumulative frequency curve at any location using only standard summarized temperature statistics as inputs. At the forefront of this effort was the U.S. military. Spreen and Manos (1952, p. 21) stated that "The demands of military operations during the last war brought into sharp relief the inadequacies of the older climatology [simplified climatographies and climate classification schemes]. Means and climatic types could not answer the questions: where, when, how often."

These predictive charts (or nomographs, as they are sometimes called) were created using the coaxial graphical correlation method (Linsley, Kohler and Paulhus, 1949). This method, still used extensively in many production, sales, chemical, forestry and hydrologic applications (Dunne and Leopold, 1978), allows general relationships to be established (in this case, between temperature frequencies and standard monthly summarized data) <u>without</u> the development of any mathematical formulae and with no assumptions as to the shape of the distribution(s) (USAF, 1955). Conversely, nomography allows the graphical representation of multiple mathematical formulas within a single chart. The coaxial graphical correlation procedure involves the successive introduction of variables and the drawing of a family of curves for each of these variables until all variables have been treated as many times as required. The procedure is a graphical iteration process of adjustment until the best-fit is obtained (USAF,1955). Various permutations of this graphical method were used to estimate temperature frequencies with varying degrees of success.

Initially, the monthly mean temperature and the difference between the mean daily maximum and mean daily minimum (mean daily range) were used as primary inputs into a family of curves generated from nine stations in diverse climatic areas (USAF, 1955; Spreen, 1956). Although the average prediction errors were less than 2°F, some predictions had errors on the order of 10° to 13°F, with the majority of these errors occurring at locations with colder temperatures (Spreen, 1956). Regardless of the magnitude of some of the errors, it is significant in that temperature distributions, from many diverse climatic locations, were brought together into a single relationship as shown

in Figure 6[3].

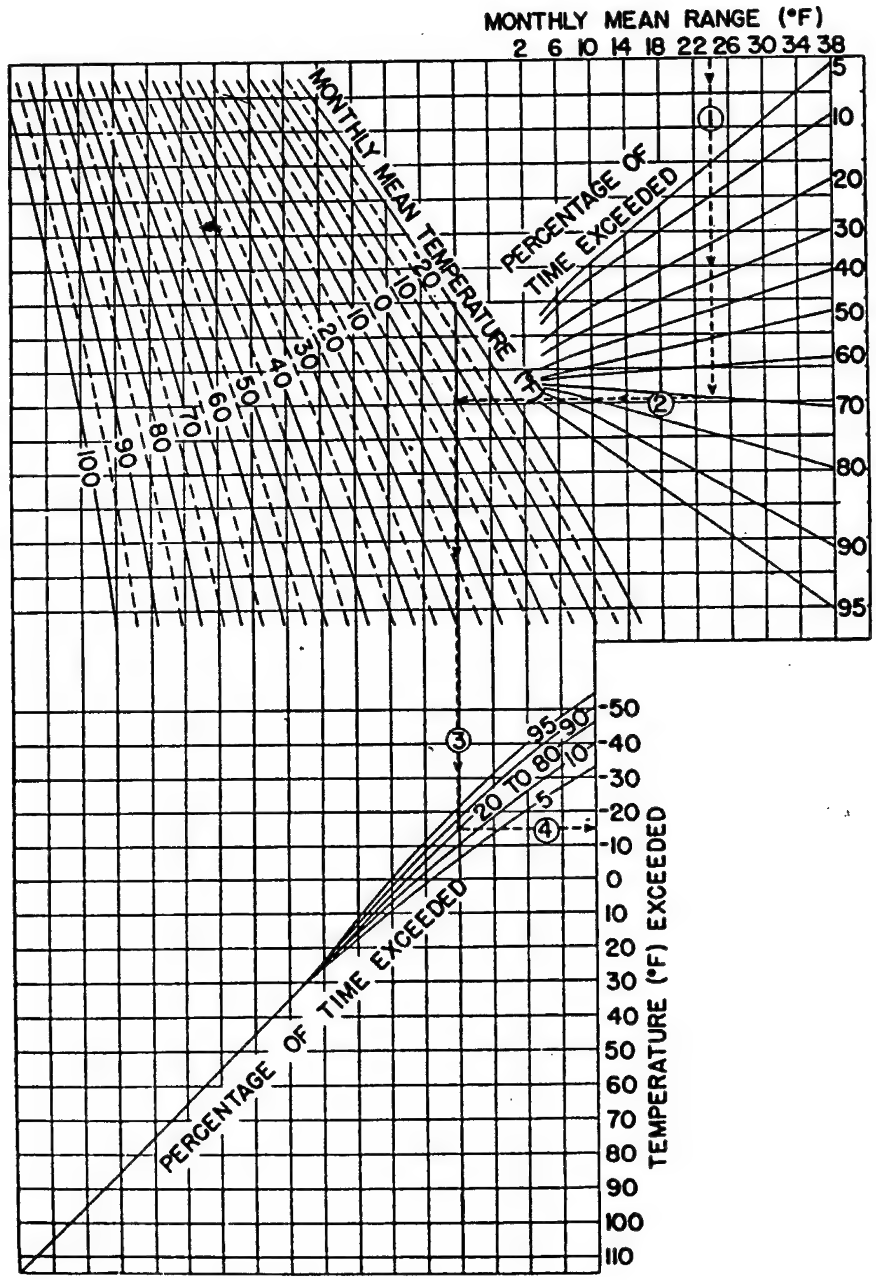

Figure. 6 Temperature Frequency Nomograph (Spreen, 1956)

[3]From "Empirically Determined Distributions of Hourly Temperatures" by W.C. Spreen, 1956, Journal of Meteorology, 13, p.352. Reprinted by permission.

This graphic method was exploited by Lackey in a series of reports spanning a 10-year period (1957-1967). Lackey experimented with various combinations of standard summarized temperatures to be used both as inputs and in nomograph construction. In his earliest works, Lackey (1957, 1958) used a method whereby monthly cumulative frequency distributions for stations within certain geographic regions were averaged together and plotted on normal probability paper. A straight line was then drawn between the averages of the extremes through the average of the means for the stations. Deviations from this normal curve at selected frequency levels were then computed and used as adjustment factors. Differences between actual temperatures and predicted temperatures ranged from 0° to 7°F. Lackey (1958) used this method with a focus on predicting daily minimum temperatures in Alaska. About 90 percent of the estimated temperatures were within 3°F from actual values, with the greatest error being 14°F.

Lackey (1960a) used the coaxial graphic method to generate an empirical nomograph to predict hourly temperature frequencies for any month at any given place where only the monthly mean temperature and the extreme maximum and minimum temperatures are known (Figure 7)[4]. Of the differences between the actual and predicted temperatures, 91 percent were 3°F or less, with the greatest difference being 7°F. In a similar article, Lackey (1960b) used his developed nomograph to estimate temperature frequencies for the winter months in North America. About 70 to 80 percent of his predictions were within 3°F of the actual values. His greatest errors, however, increased from 7°F (Lackey, 1960a) to 14°F.

Lackey's early works (1960a, 1960b) mirrored that of Spreen (1956) and, similarly, the extreme prediction errors occurred at stations experiencing the coldest temperatures and were of about the same magnitude. It is significant to note that there is neither mention of nor use of any stations with extreme cold temperatures in two later reports (Lackey 1964, 1967). It is obvious that the difficulties Lackey encountered in predicting temperature frequencies at low temperatures had not yet been satisfactorily rectified.

Lackey enhanced the predictive quality and overall complexity of his nomographs in later attempts to predict maximum temperatures for any summer month (1964) and daily minimum temperatures for any winter month (1965). He also created what he termed a 'General-Purpose' nomograph (Figure 8) that had applicability to climatic elements in addition to temperature (1967). As Lackey strove to enhance and expand the predictive capability of his nomographs, the nomographs themselves grew exceedingly complex and the procedural instructions became almost incomprehensible. Perhaps one reason why no reference to Lackey's work could be found in subsequent articles on the

[4] From "A Method of Assessing Hourly Temperature Probabilities from Limited Weather Records", by E.E. Lackey, 1960, Bulletin of the American Meteorological Society, 41(6), p. 299. Reprinted by Permission.

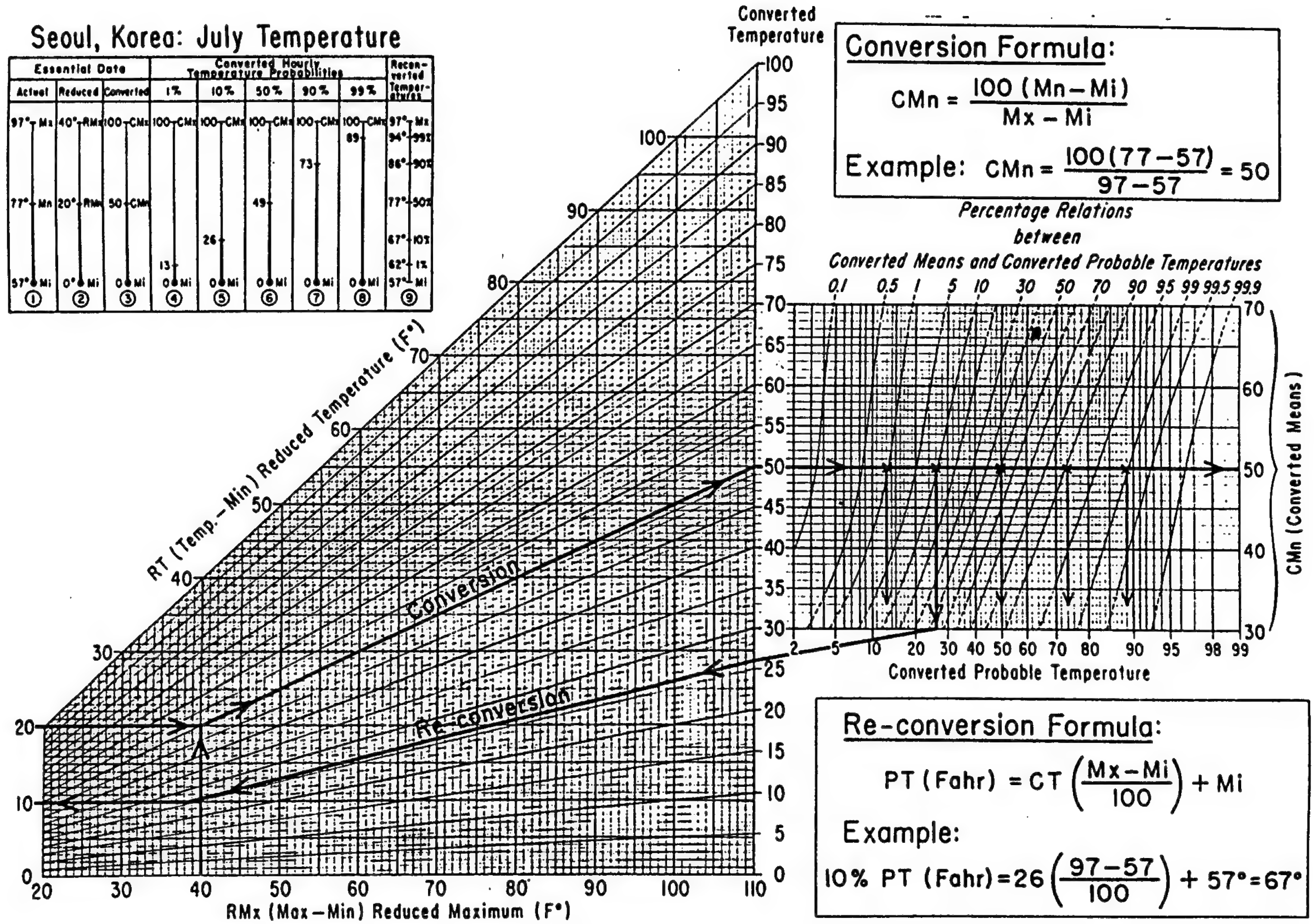

Figure 7. Hourly Temperature Nomograph (Lackey, 1960a)

subject of temperature frequency prediction can be attributed to the overall complexity of these later nomographs. Another reason is that Lackey published mostly in military literature which, as a rule, had little outside distribution to the academic community.

In addition to the refinement of his nomographs, Lackey's later works (1964, 1967) also focused on the effects of the length of a station's period-of-record on nomograph accuracy. Periods-of-record for the temperature data in both Spreen's and Lackey's early works were extremely small by today's standards. In many instances, they were on the order of three to five years. Short periods-of-record for climatological data may cause the conclusions drawn from any statistical method to be highly suspect. The length of the period-of-record for a climatological element depends on, among other factors, the natural variability of the element in question, climatic area, etc. As a general rule, the length of the period-of-record should exceed 10 years and, ideally, be on the order of 25 to 35 years (Conrad and Pollack, 1950). Most often, a continuous 30-year period ("normal period") is used as a standard (NOCD, 1992). Short periods-of-record probably accounted for some of the poor predictive capabilities at the tails of the distributions.

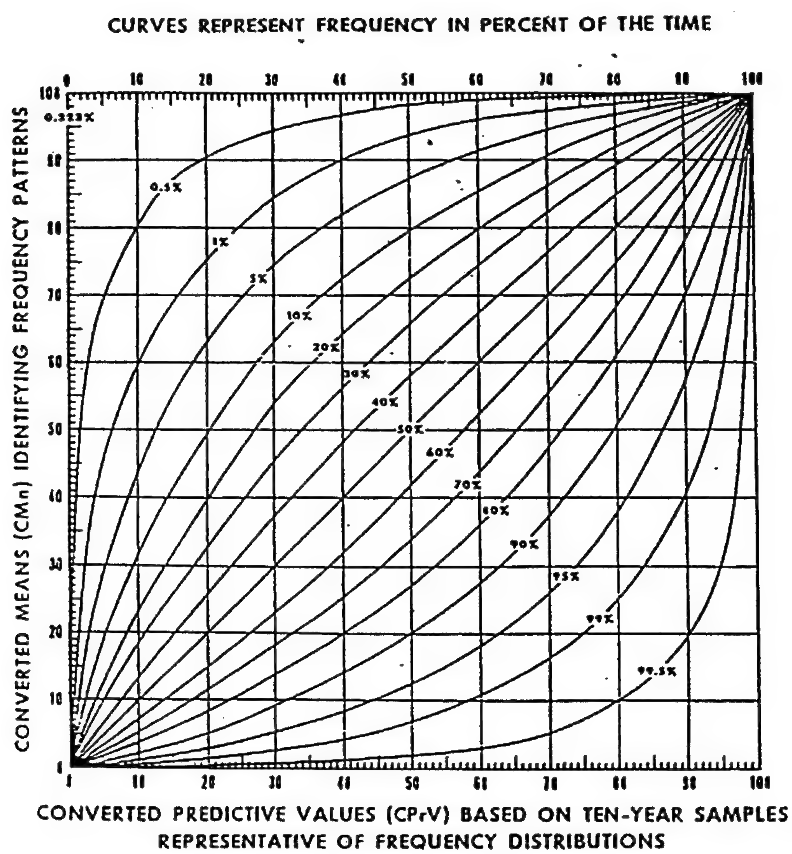

Figure 8. General Purpose Nomograph (Lackey, 1967)

Nevertheless, these works represent the last research that could be located in which non-statistical, graphical techniques were solely used to predict temperature frequencies. These also represent the "last" set of works that treated the frequency curve in its entirety. More current research has been mathematical in nature and has focused on certain portions of the frequency curve or on specific temperature frequency levels.

Statistical Relationships and Estimation

The impetus for the development of techniques applicable to the estimation of temperature frequencies was provided by the building design, equipment design and heating and air conditioning communities. An early attempt at quantitatively investigating summarized temperature values and temperature frequency relationships was noted by Boyd (1955). In the mid-1950s, H.C.S. Thom had noted a linear relationship between a) the standard deviation of the mean monthly temperature and b) the difference between the mean monthly temperature and certain temperature frequency levels. Boyd examined this relationship and found it to be sufficiently accurate to create a series of temperature frequency maps. These maps were used in the National Building Code of Canada for the establishment of building design criteria (Boyd,1955).

Crow (1963), working at estimating temperatures for heating and air conditioning design, developed a method for estimating summer and winter temperature frequencies. Using the median value of both the hottest and coldest annual extremes as a summer and winter base, respectively, Crow determined the number of degrees difference between these median values and actual 1 percent, 2.5 percent and 5 percent high and low temperature levels for summer and winter seasons at 160 stations in CONUS. These differences were then plotted as isopleths on maps to serve as adjustment factors when estimating temperatures at the three statistical levels (Figure 9)[5]. If other frequency levels are desired, Crow states that they can be derived through the use of "...elementary statistical techniques and probability graph paper..." (Crow, 1964, p. 73)-- although the method for accomplishing this is not given. This methodology of estimating temperature frequencies was adopted by the heating, air conditioning and ventilation community in the U.S. (ASHRAE, 1989; Ecodyne, 1980). Conversely, similar temperature frequency information found in the current National Building Codes of Canada for stations with no available hourly temperature data, was derived through pure, subjective interpolation. All estimations were made "...without using any intermediate statistic..." (Boyd, 1985, p. 5).

[5] From "Derivation of Outdoor Design Temperatures from Annual Extremes," by L.W. Crow, 1964, ASHRAE Transactions 1964, 70, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., Atlanta, GA. Reprinted by permission.

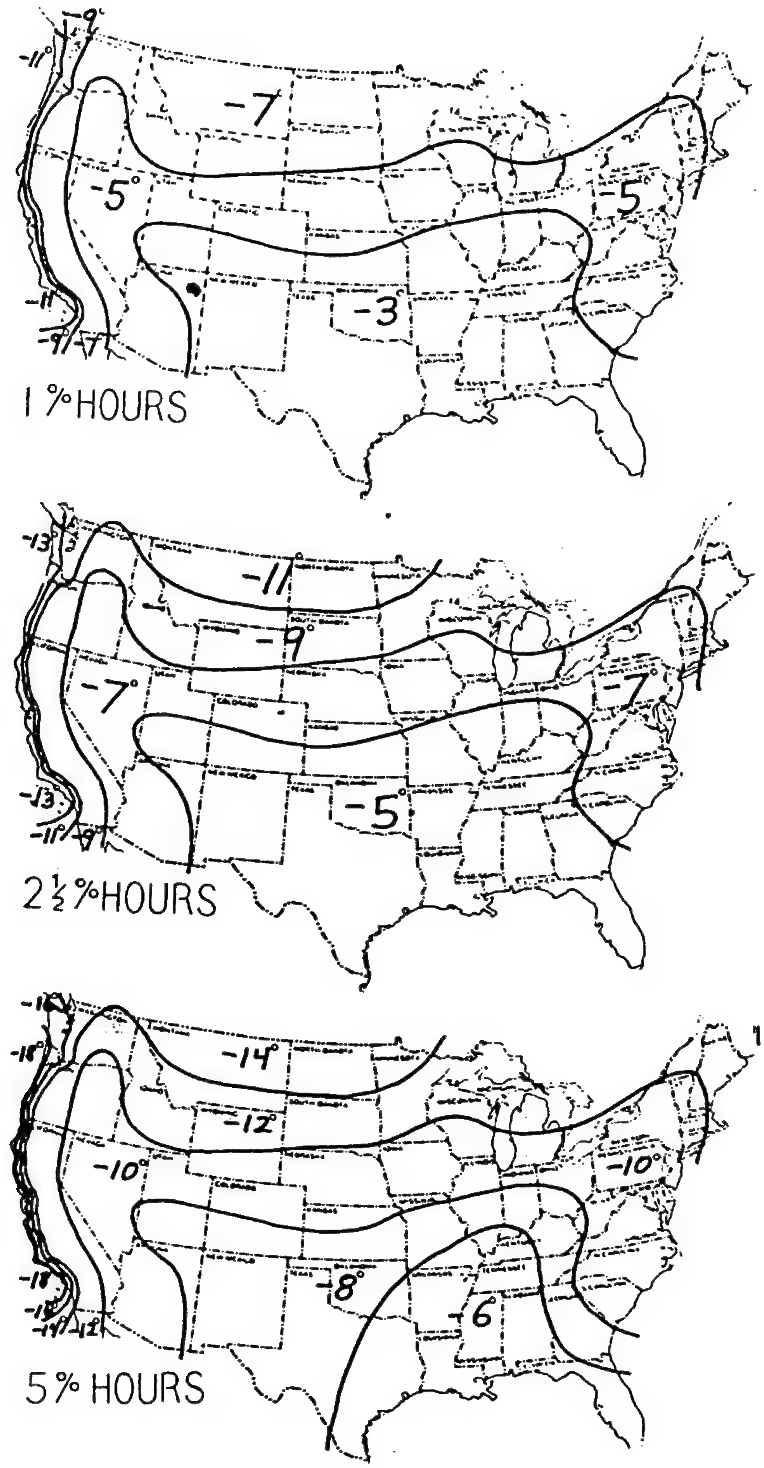

Figure 9. Adjustment Factors for Deriving Annual Percentile Levels of Hours for Summer Months (Crow, 1964)

Crow's work, however, illustrates that there are certain relationships between the various standard summarized temperature statistics and certain selected frequency levels. His maps also show that there is some geographic basis underlying his generated adjustment factors. However, map generation of this type requires a dense network of stations to arrive at statistically legitimate adjustment factors to provide a level of confidence during interpolation between the isopleths. This is especially true in areas of diverse topography. In addition, most foreign countries do not possess the requisite number of stations with hourly temperature values to make this technique viable. Also, the distribution of extreme values, a required variable for this method, is not always available to the researcher.

Tattelman and Kantor (1977), working in the area of developing climatic criteria for military equipment design, formulated a method whereby 1-, 5- and 10-percentile temperature frequencies for the warmest and coldest months could be derived from selected summarized data. For high temperatures, they created the following simple index which took the form

$$I_w = T_m + (T_x - T_n) \qquad (2)$$

where I_w is the warm temperature index, T_m is the mean temperature (°C) of the warmest month, T_x is the mean daily maximum temperature (°C) and T_n is the mean daily minimum temperature (°C). For the coldest month the index becomes

$$I_c = T_m - (T_x - T_n) \qquad (3)$$

with the input temperatures the same except now they are for the coldest month. Index values were then computed for 40 stations for the hottest month and for 43 stations for the coldest.

The Index values for each station were then regressed, in turn, with actual 1-, 5-, and 10-percentile temperatures for both the hottest and coldest month. This generated three least squares linear regression lines for the hottest month and three for the coldest. Figure 10 shows the three curves for the hottest month that were generated by this author from the equations developed by Tattelman and Kantor. The results showed high correlations for all six generated equations (ranging from 0.97 to 0.99). Standard errors averaged 2.25°F for the warmest month equations and 4.55°F for the coldest month equations. There were, however, a number of outliers on the order of 9-18°F for the coldest month. For two of the outlier stations, the authors attribute the poor fit to the

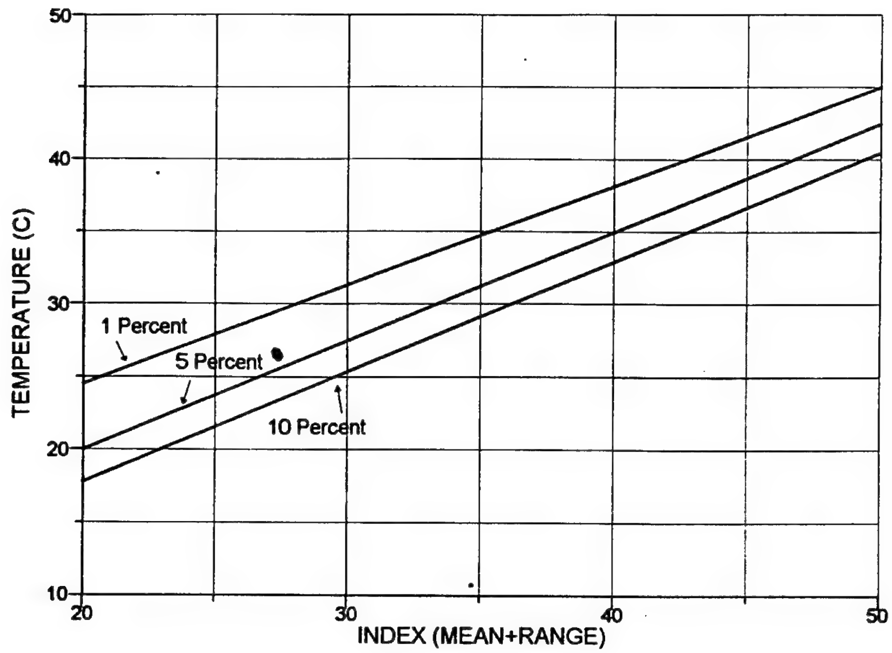

Figure 10. Composite 1-, 5-, and 10-Percentile High Temperature Curves for the Hottest Month (derived from equations appearing in Tattelman and Kantor, 1977)

limited number of hourly observations per day at the respective sites. Tattelman and Kantor do not discuss the rest of the stations that were significant outliers.

The above method is predicated on the notion that the hottest temperatures occur at stations having a high mean temperature and high daily range and, conversely, that the coldest temperatures occur at stations having a low mean temperature and high daily range. This method appears to work moderately well in most geographic areas for these two extreme months and demonstrates that a relationship does exist between certain frequency levels and various summarized statistical values. However, there is no indication whether the developed model is applicable to other less extreme months when stations are not experiencing their warmest or coldest temperatures.

Doesken and McKee (1983) examined the estimation of low temperature design extremes in a rather small geographic region for the winter season (December through February). Using 15 years of hourly and daily minimum temperature data from seven stations in Colorado, they developed a procedure to estimate any point on the low-probability portion of the hourly temperature curve from a knowledge of the cumulative curve of daily minimum temperatures. For this application, the best fit curve was determined to be a power function of the form

$$P = a(T - T_o)^b \qquad (4)$$

where P = the probability of non-exceedence, a is the y-intercept and b is the slope, T is the temperature at that probability, and T_o is the reference origin temperature (an artificial value, lower than the extreme minimum temperature, and used to anchor the curve at its lowest point). Trial and error was used to obtain the best fit curve. Only a portion of the actual low temperature curve could be used for equation development. That portion was selected to maximize the estimation accuracy at the desired statistical levels. Results were fairly good for the seven stations used in the study. Generated temperatures at any given probability level were usually within 1.26°F of the observed value. Extrapolation of this technique to other geographic areas produced results that were "not as consistent" as in Colorado -- differences of as much as 5.4°F were common.

A study, similar to the aforementioned report, dealt with the estimation of summer high temperature design frequencies using 15 years of hourly and daily temperature data from six stations in New Mexico (Kunkel, 1986). Unlike the power curve which was the best estimator for low temperatures (Doesken and McKee, 1983), the exponential form provided a better fit. The general form of the equation was

$$P = 1 - e^{-a(T-T_o)^b} \qquad (5)$$

where P = the probability of non-exceedence, a is the Y-intercept, b is the slope, T is the temperature at that probability, T_o is the reference origin temperature (see Doeskin and McKee, 1983, above), and e is the base of natural logarithms with an approximate value of 2.7183.

Once again, only a portion of the curve was used to maximize accuracy at desired probability levels. The results show extremely good estimation at selected probability levels, with the average difference being 0.32°F and the largest difference being 1.62°F. Kunkel also develops a linear relationship between design temperature values and elevation. Similar to Williams' findings (1972), Kunkel's model performed best at locations above 1,500 feet elevation. Below this value, the relationships deteriorated almost to insignificance. Additionally, Kunkel cautions that these methods and relationships might not be applicable to other geographic areas (especially those with small ranges in temperature) and probably would not apply to other seasons such as spring and autumn.

Extreme Value Analysis

Another body of related research, extreme-value analysis, has dealt exclusively with the extreme upper and lower portions (tails) of frequency distribution curves for many meteorological and climatological elements. Whereas this work involves the

estimation of the occurrence of temperatures that have occurred (with applications for future occurrences), the primary focus of extreme value analysis is on estimating the greatest or smallest value that an element can reach and how often this value will occur during some discrete time period (Gumbel, 1958). Many extreme value statistical tests and models have been proposed over the years to best estimate the distribution of extreme values of various elements (Jenkinson, 1955; Gumbel, 1958; Gringorton, 1960, 1963; Nicodemus and Guttman, 1980; Tiago de Oliveira, 1986). Compilations of the various methods can be obtained in Essenwanger (1976) and Farago and Katz (1990). One of the focuses of extreme value research, namely high temperature, has become extremely topical in view of the global climate warming issues that have arisen recently (Mearns, Katz and Schneider, 1984; Wigley, 1985, 1988; Idso and Balling, 1992; Vedin, 1990; Balling, Skindlov and Phillips, 1990; Katz and Brown, 1992). Although not specifically dealing with the entire temperature frequency distribution, this body of literature has as its focus the tails of the frequency distribution -- most of the past difficulties in predicting temperature frequencies have occurred within the tails of the distribution.

Summary of Previous Temperature Frequency Estimation Research

Interest in estimating monthly temperature frequencies from summarized monthly values has been largely applications driven. The heating and air conditioning, equipment design and military communities have generated practically all of the literature in this research arena. Research in this area has followed the cycle: 1) map displays of selected temperature frequency levels (Visher, 1946, 1954); 2) graphs showing relationships in the tails of the distribution (Meigs, 1953; Williams, 1972); 3) mathematical attempts at grouping (Clark, 1954); 4) maps showing mathematical relationships (Court, 1951; Boyd, 1955; Crow, 1963); 5) empirical graphics schemes (USAF, 1955; Spreen, 1956; Lackey (1957, 1958, 1960a, 1960b, 1964, 1965, 1967); and, 6) mathematical models to predict temperatures at selected frequency levels within the tails of the cumulative frequency distribution (Tattelman and Kantor, 1977; Doesken and McKee, 1983; Kunkel, 1986).

One common feature of practically all of the referenced literature on this topic is that the authors either intimated, stated directly,or had data analysis to show a geographic basis for the nature of a station's temperature frequency distribution. Court (1951) discusses both geographic and meteorological factors (chiefly moisture) contributing to the characteristics of his U.S. temperature frequency regions. Meigs (1953) creates a predictive relationship that works well for hot-dry areas but acknowledges that the generated relationship does not adequately predict temperature frequencies in hot-humid areas. Clark (1954) points to air masses and topography as two of the primary factors in shaping temperature distribution characteristics. The nomographs of Spreen (1956) and Lackey (1960b) exhibit fair predictive performance except for extremely cold stations. Crow (1963) discusses the frequency of air mass types when explaining the geographic patterns of his mapped adjustment factors. Williams (1972) and Kunkel (1986) showed a

relationship between high temperature percentile levels and standard summarized station climate data at elevations above about 1,500 feet. Tattelman and Kantor's (1977) regression outliers of the greatest magnitude occurred at extremely cold stations, high elevation sites and several coastal locations. The relationships developed by Doesken and McKee (1983) and Kunkel (1986) appear to be applicable to only fairly homogenous and/or specific geographic regions. Doesken and McKee (1983) also demonstrate the differences in design temperature characteristics between basin and valley locations that are cold air-trapping sites and the more windswept ridge tops and mountain passes.

Prior research has shown then that the characteristics and morphology of a station's hourly temperature frequency distribution is shaped, in large part, by the impact of a number of topographic and climatic factors. Hence, if these factors can be incorporated into a model that permits a station to be assigned to a group whose members have a commonality in topographic and climatic characteristics, then procedures can be developed to allow the estimation of the frequency of occurrence of any desired temperature at that station. The following section focuses on the model that was selected to enable a station to be assigned to a group so that temperature frequency estimation is possible. Station attribute data, both topographic and climatic, are also discussed as to their possible impacts on a station's temperature frequency curve. Data preprocessing techniques also are explained. Preliminary runs of the selected model are outlined, as are curve-fitting methods to represent the cumulative frequency distribution.

MODEL, DATA SELECTION AND PREPROCESSING

This section focuses first on the choice of a model that will permit a station to be assigned to a group by using a station's attribute data and then, once assigned, will permit the frequency of occurrence of temperature to be readily estimated. Also discussed is the selection of stations whose attribute data will be used as input to the model. As it required a great deal of time to accomplish, the preprocessing procedures on the data will be explained along with the creation of model building and validation data sets, the establishment of error criteria and the types of data output that the model produces. This section concludes with a discussion of fitting a curve to the group mean normalized temperatures and preliminary model runs to fine tune the overall procedures required to perform the entire analysis.

Although these aforementioned activities encompass many different types of discrete tasks, they are all part of a step-by-step process that was required to arrive at a finished product. To help clarify this process, Figure 11 is provided as a guide to chart the flow of these activities. The elements of this flow chart provide the major activity at each step of the process, with elaboration appearing in the general text found throughout this section.

Model

The statistical technique selected to place stations into groups based on the commonality of their topographic/climatic attributes is discriminant analysis. Discriminant analysis is a technique that defines the linear combination of independent (predictor) variables that maximizes the differences between groups. Using the derived functions (termed classification or discriminant functions), one assigns cases (climate stations) to groups. One basic assumption of discriminant analysis is that the data cases should be members of two or more mutually exclusive groups. The groups must be defined so that each case belongs to one group, and one group only. We seek to minimize the within-group variance and maximize the between-group variance. The derived functions will act to combine group characteristics in such a way as to allow one to identify a group to which a case (climate station) most closely resembles. In using discriminant analysis, we also seek to establish which characteristics (independent variables) are important in distinguishing among the groups and evaluate the accuracy of the classification. The software of choice was BMDP's "Stepwise Discriminant Analysis" (BMDP-7M, 1992a). Version 7.01 was used. This is a DOS-based rendition of the same software used on

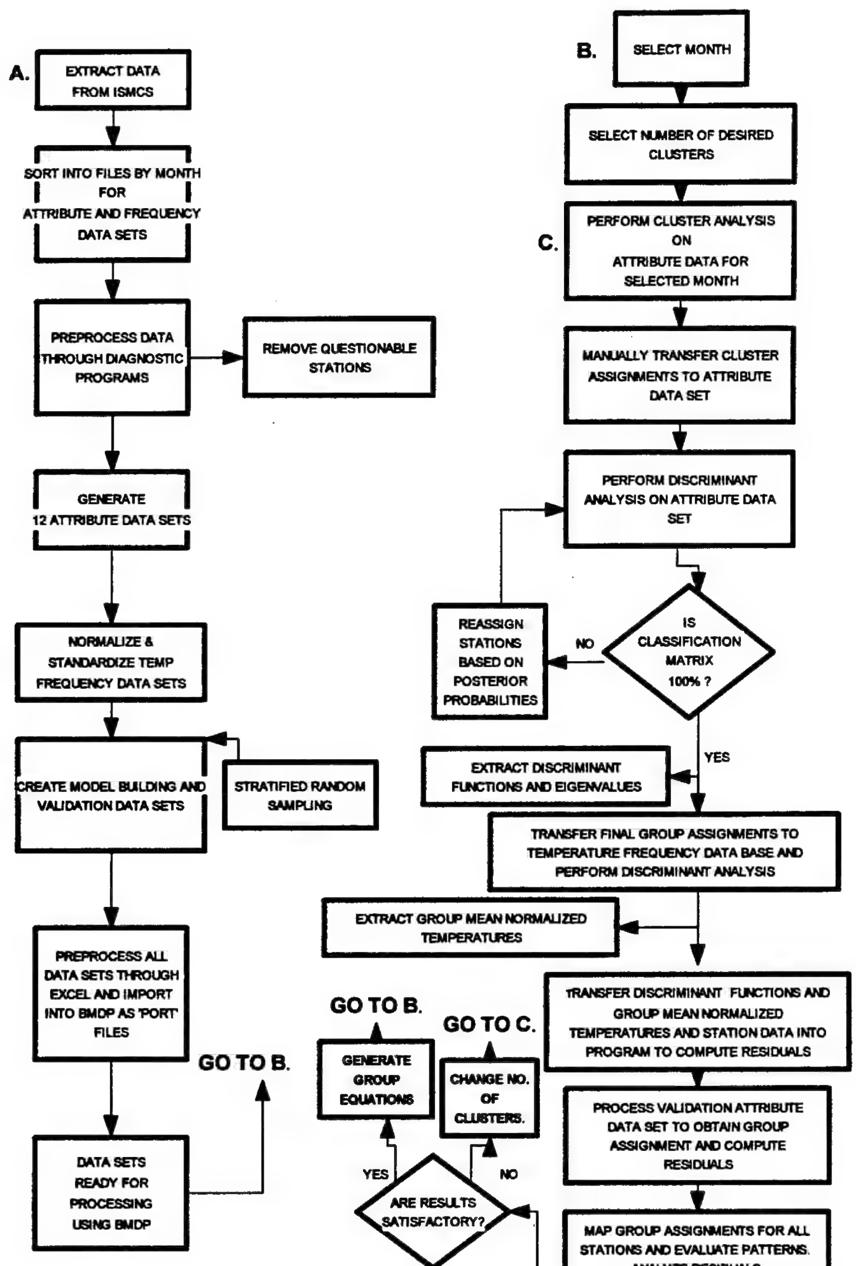

Figure 11. Process Flow Chart

mainframe computers.

Two data bases for each month are required for input into the model. The first is comprised of attribute variables (topographic and climatic) for each of the stations for each month. The second required data base contains the cumulative hourly temperature frequency distribution data for each of the stations for each month. The following discussion concerns itself with the choice of attribute variables, the rationale for their selection, and the common data source that provided both the attribute variables and the cumulative hourly temperature data required for model input.

Station Attribute Data

Topographic and climatic variables were selected on the basis of two primary criteria. First and foremost, their relationship to the morphology of a station's temperature frequency curve must have been either demonstrated or intimated in previous professional literature. Second, the variables should be common enough so that they are available or can be derived for all the stations to be used in model development. A total of eight attribute variables were selected -- two topographic and six climatic.

A. Topographic

Two topographic variables were chosen. These variables are common and would appear on any climate summary.

1. Latitude

Ahrens (1991) points out that latitude is one of the primary controls of climate. A number of prior studies have used the element latitude as either an input or a consideration (Driscoll and Yee Fong 1992; Leffler, 1981; Tattleman and Kantor, 1977; Ecodyne, 1980). It is an implicit assumption that a station's latitude would have a bearing on the nature and characteristics of its temperature curve. As a general rule, temperature ranges increase with increasing latitude away from the equator. In another example, maps showing temperature adjustment factors (see Figure 9) exhibit a distinct latitudinal trend over the eastern two-thirds of the U.S. Latitude will assist in the evaluation of the relationship between stations in similar climatic areas and may provide a way of assessing the rate at which temperature distributions change when moving north or south of a given point.

2. Elevation

The nature of the temperature distribution with changes in elevation has been the subject of numerous articles. Ahrens (1991) lists elevation as one of the major controlling

factors of climate. In general, large changes in elevation can cause rapid changes in temperature frequency values over very short horizontal distances (Ecodyne, 1980). Temperature ranges also are affected by elevation and latitude factors (Leffler, 1981; Schmidlin, 1982). Williams (1972) and Kunkel (1986) demonstrated a relationship between temperature percentile levels and summarized temperature levels at high elevations in the U.S. Southwest.

B. Climatic

A total of six climatic variables were chosen. These required data are common temperature and precipitation variables and are available on common climate summaries.

1. Precipitation Effectiveness (P/E) Index

Moisture acts to control the variability of air temperature (Court, 1951). Water on the ground, in the ground and in the air reduces the daily temperature range and the spread of hourly temperature distributions. Drier air permits slightly higher maximum temperatures and much lower minimum temperatures than does moist air.

Using the concept that the effectiveness of any given amount of precipitation decreases with an increase in temperature, C.W. Thornthwaite developed a "Precipitation Effectiveness Index" or "P/E Index" (Stadler, 1987). This index is easily computed using the following formula (Conrad and Pollack, 1950)

$$\text{P/E Index} = 115[P_n / (T_n - 10)]^{10/9} \qquad (6)$$

where P/E Index is the Precipitation Effectiveness Index, P_n is the average precipitation in inches for the nth month and T_n is the average temperature (°F) for the nth month. Each month's value is computed and totaled to arrive at an annual total. During computation, all mean temperatures less than 28.4°F are given the value 28.4°F. Monthly P/E ratios greater than 40 are counted as 40 (Huschke, 1959). The annual value places a station into one of five humidity provinces based on the following criteria:

P/E Index	Province
128 and above	Wet
64 to 127	Humid
32 to 63	Subhumid
16 to 31	Semiarid
Under 16	Arid

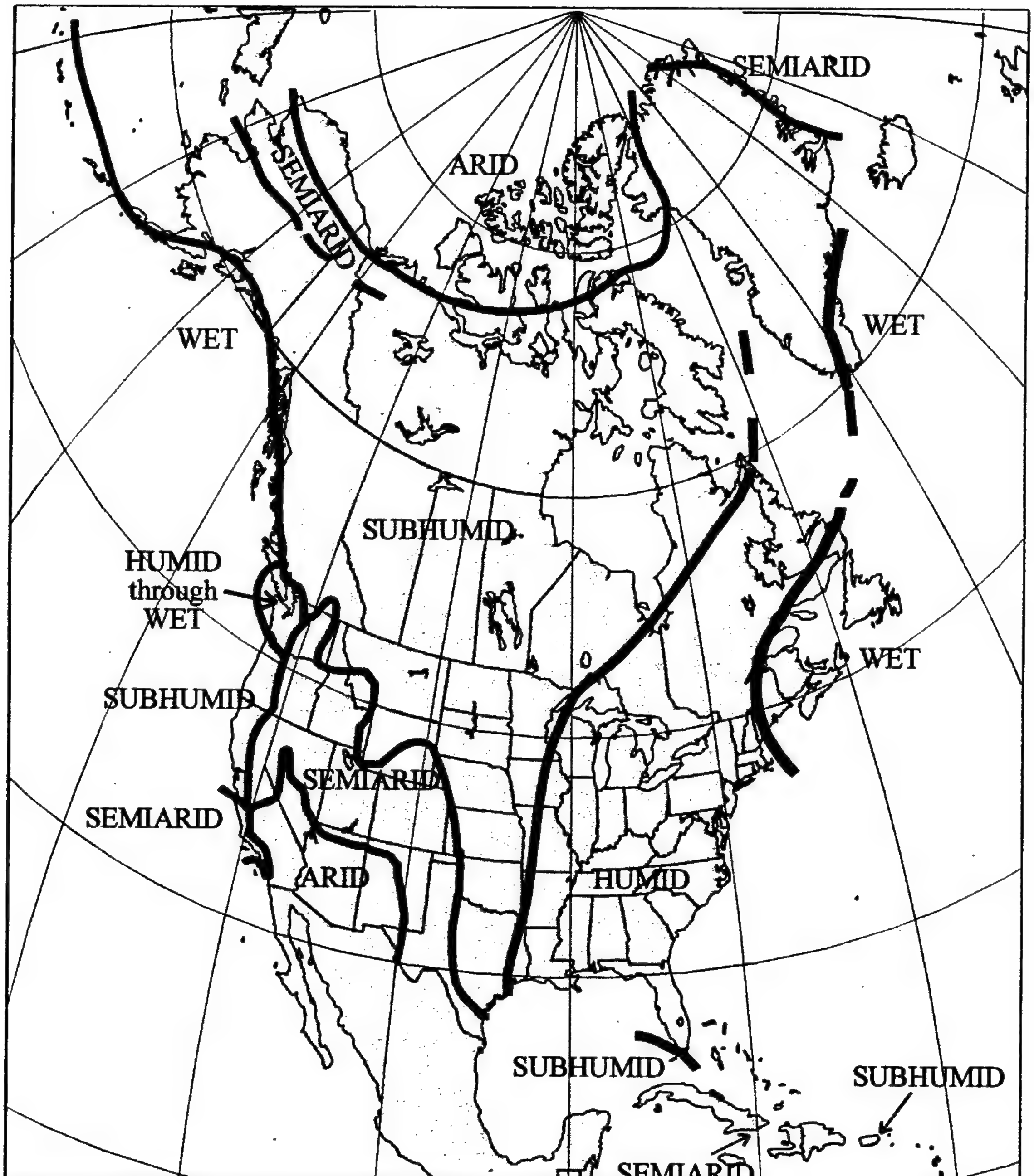

FIGURE 12. PRECIPITATION EFFECTIVENESS (P/E)
HUMIDITY PROVINCES
FOR
NORTH AMERICA
(based on values for 276 stations)

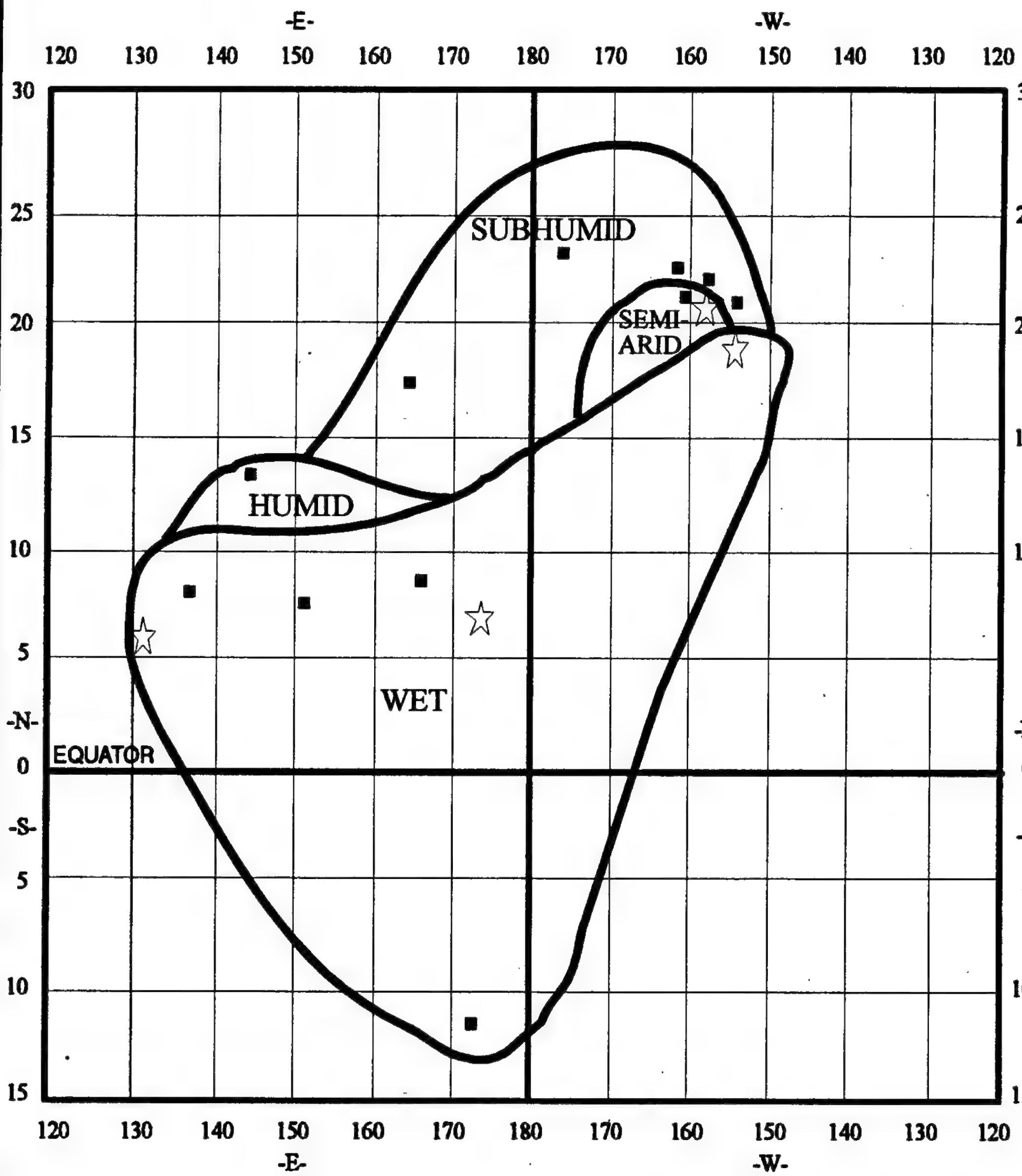

FIGURE 13. PRECIPITATION EFFECTIVENESS (P/E)
HUMIDITY PROVINCES
FOR
PACIFIC ISLANDS

This index will further assist in grouping the stations into categories that reflect moisture's role in modifying the thermal environment. Maps showing the general P/E regions for North America and the Pacific islands were cartographically compiled from the data used in this study and appear as Figures 12 and 13, respectively.

2. Continentality

Continentality is a derived climatic attribute that recognizes the low specific heat and poor conductivity of land vis-a-vis water (Duckson, 1987). Areas of high continentality are characterized by large annual ranges of temperature, relatively high summer temperatures and cold, dry winters. Theoretically, the highest values of continentality should occur at the center of a continent. Continentality's opposite is oceanicity or maritime coefficient. A continentality index will provide an indication of the spread of the temperature distributions and will further help subdivide the broad climatic types into more discrete and meaningful regions.

As with climate classification systems, there are a number of continentality indices that have been developed. Common elements of these indices are some measure of a location's temperature range and a latitude factor. More recent research on the development of a new index (Driscoll and Yee Fong, 1992) still used these two basic elements in index development. Practically all of these indices are derivations of a formula developed by Zenker in 1888 (Duckson, 1987). One such common derivation of Zenker's formula is the index developed by Conrad in 1946 (Trewartha, 1961; Duckson, 1987). Conrad's continentality formula is

$$K = [1.7A / \sin (L+10)] - 14 \qquad (7)$$

where K is the Continentality Index, A is the mean annual temperature amplitude (°C) of a location (difference between the mean temperature of the hottest month and mean temperature of the coldest month) and L is the latitude of the location in decimal degrees.

These sets of continentality indices all incorporate two common elements -- a location's mean annual temperature amplitude (°C) and the station's latitude. They all produce index numbers (at different scales, of course) in which low values signify oceanicity (or maritime influence) and high numbers indicate continentality. According to Conrad and Pollak (1950), using the above formula (7) would yield a value near 100 for high continental locations, such as central Siberia, and a value close to zero for coastal tropical areas. They also discuss some of the limitations of various indices that are derivations of Zenker's original model. All appear to have trouble within tropical regions, with negative values a possibility (Conrad and Pollak, 1950). Maps showing the general continentality regions for North America and the Pacific islands were cartographically

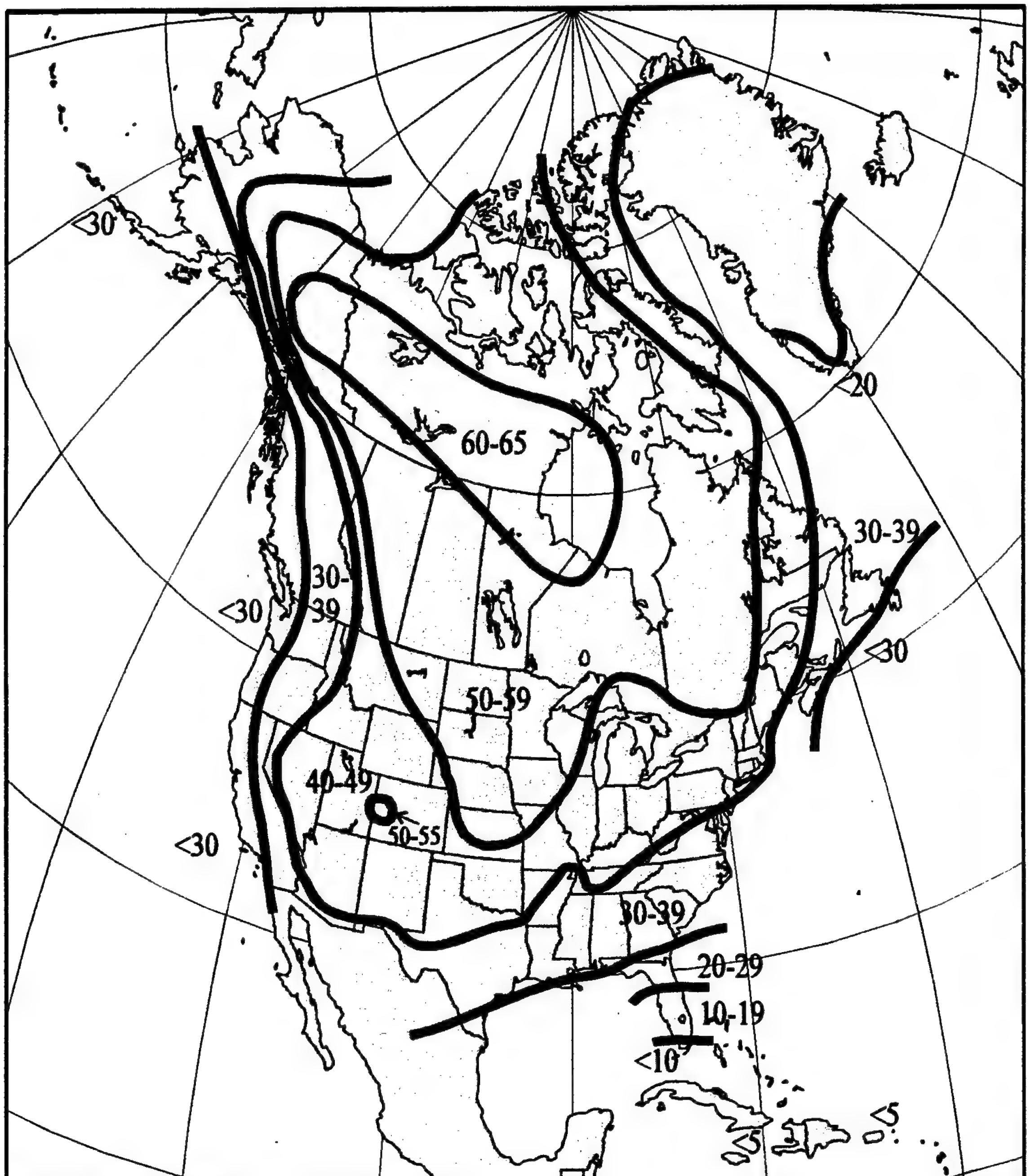

FIGURE 14. CONTINENTALITY (Conrad's 'K') VALUES
FOR NORTH AMERICA
(based on values for 276 stations)

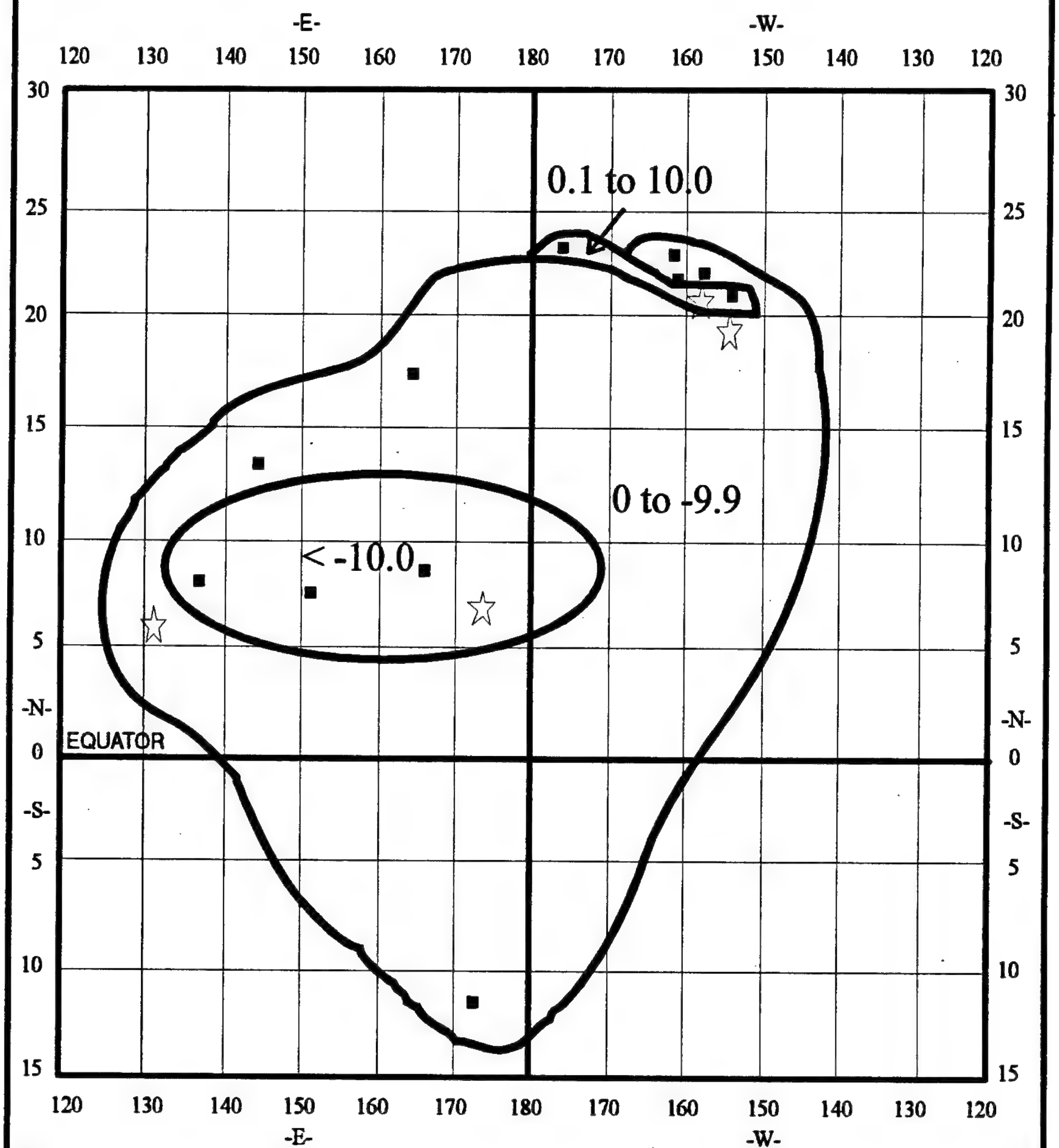

FIGURE 15. CONTINENTALITY (Conrad's 'K') VALUES FOR PACIFIC ISLANDS

compiled from the data used in this study and appear as Figures 14 and 15, respectively.

3 & 4. Monthly Temperature Range and Daily Temperature Range

Monthly temperature range can be defined as the difference between the absolute maximum temperature and the absolute minimum temperature. Daily temperature range is the difference between the mean daily maximum temperature and the mean daily minimum temperature. As a general rule, monthly temperature ranges tend to be the greatest at interior locations, during the winter months, and at higher latitudes. They are smallest at coastal locations, more humid sites, and tropical areas.

Daily temperature ranges tend to be the greatest at high desert and in mountainous locales. They are smallest at coastal areas, at more humid sites, and at tropical locations. For many locations they also tend to be greater during the summer months with strong heating during the day and rapid radiational cooling at night. As an example of several large diurnal ranges at high desert locations, Ahrens (1991) showed Reno, Nevada's average July daily range of 45°F. Krause (1980) investigated 10 years of daily maximum and minimum temperatures and found that in CONUS the majority of stations with extremely large diurnal ranges were located in the Great Basin. The record diurnal ranges for four major Nevada cities for the 10-year period were Reno (57°F), Winnemucca (61°F), Elko (56°F) and Ely (54°F). Trewartha (1968) states that the windward sides of mountains have smaller temperature ranges than do the leeward slopes as well as more temperature variability. Both monthly and daily temperature ranges, therefore, can help differentiate between coastal and interior stations, windward-leeward sites, wet and dry stations, and tropical and non-tropical stations.

5 & 6. Normalized Mean Daily Maximum Temperature and Normalized Mean Daily Minimum Temperature

Court (1951) used the element of distributional skewness as one factor in the development of his temperature frequency regions in CONUS. Clark (1954) also used skewness as one of the variables to assign stations into specific "Temperature Frequency Types." As discussed by Lackey (1965), if a temperature frequency distribution was normally distributed and then normalized on a scale of 0 to 100, then the mean monthly temperature would be 50 and the mean daily maximum temperature and mean daily minimum temperature would be on opposite sides of 50 and equidistant from this value. If, for example, the normalized mean daily maximum and minimum temperatures had low values on the normalized scale, it would indicate that the bulk of the distribution was on the left side (i.e., a right or positively skewed distribution). Conversely, high values of these measures would indicate a left or negatively skewed distribution.

A simple equation to normalize these required temperatures takes the form

$$T_{norm} = (100/mrange) \times (T_i - T_{absmin}) \qquad (8)$$

where T_{norm} is the derived normalized temperature, mrange is the station's monthly temperature range (difference between the absolute maximum and absolute minimum temperatures), T_i is the input temperature, and, T_{absmin} is the absolute minimum temperature. The normalized mean daily maximum and mean daily minimum temperatures will provide an indication of the generalized skewness of the overall temperature frequency distribution and can help corroborate prior research into the relationship of skewness to the morphology of the temperature frequency distribution.

Data Source

Ideally, a common data source for the aforementioned topographic and climatic variables is desirable. The most reliable data source proved to be the "International Station Meteorological Climate Summaries" (ISMCS) (NOCD, 1992). The ISMCS, a CD-ROM data base, contains an extensive worldwide set of climatic data for 6,371 civilian and military stations. The ISMCS CD-ROM was developed as a cooperative effort of the U.S. Navy, U.S. Air Force and the U.S. National Climate Data Center (NCDC). The ISMCS provides the necessary information to extract and/or derive the station attribute data and, for many first-order civilian and military stations, also contains monthly tables of hourly temperature counts in two-degree class intervals.

Station Selection

In order to provide a fairly dense distribution of stations, the North American continent was chosen as the geographic area for analysis. This additionally provides a contiguous surface for the subsequent mapping of the discriminant function groups. Additional National Weather Service (NWS) stations in the Pacific Ocean also were chosen so that tropical stations could be included in the analysis. A survey of the ISMCS uncovered 288 stations in these geographic areas that possessed the requisite data tables. Station locations range from 12°S to roughly 83°N latitude and from sea level to over 6,200 feet in elevation. This coverage provides representative stations from coastal to mountainous locations and in all the major climatic types except for Ice Cap Climate (modified Koeppen "EF") of the Greenland Plateau (Oliver and Wilson, 1987) for which no stations with sufficient data could be uncovered.

Data Extraction and Preprocessing

Since the ISMCS does not possess a tool to allow the bulk extraction of data tables, the task was performed manually. Thirteen files for each of the 288 stations were required -- a climate summary table (a sample is provided as Table 2) containing the data to generate the attribute data base and 12 monthly temperature frequency tables (a sample is provided as Table 3). These files for each station were manually extracted from the ISMCS, creating 3,744 (13 x 288) individual files. The temperature frequency files were then sorted into bulk files for each individual month and underwent a check for consistency.

At this point, in order to assess the overall quality and consistency of the data sets prior to their processing, a diagnostic program was written to examine the data. Stations that did not pass this diagnostic were flagged and then visually examined. Overall, 10 stations were removed after passage through the various diagnostic programs. The first diagnostic program looked for consistencies between the monthly data summaries and the temperature frequency tables for each of the candidate stations. Six of the 10 stations possessed monthly temperature frequency tables that did not correspond to the monthly temperature range set forth in the data summary. For example, a station's July extreme maximum might be given as 95°F in the climate summary, but the temperature frequency table showed observations only going as high as 91°F. A diagnostic program also was devised that graphically displayed the frequency counts of temperature. This program uncovered that the frequency distributions for two stations did not follow a typical bell-shaped distribution. They possessed what appeared to be a great deal of missing observations in the middle of the distribution that gave them an almost bimodal appearance. These two stations were removed. And finally, two of the stations were accessing the same temperature frequency tables in the ISMCS. At this point, 278 stations remained for analysis purposes. A program was then developed that created the 12 monthly attribute data sets, each containing the eight topographic/climatic variables for each of the 278 stations.

Temperature Frequency Distribution Normalization

In order to compare the temperature frequency distributions, the influence of actual temperatures must be removed (Lackey, 1965). This was accomplished through the normalization process (Equation 8). Actual temperatures in the cumulative frequency distributions were converted to a scale of 0 to 100, with 0 respresenting the extreme monthly minimum temperature and 100 representing the extreme monthly maximum temperature. Thus, if two stations possess the same basic shape in their monthly temperature frequency curves, but have different actual temperatures, the normalization

Table 2. Sample ISMCS Climate Summary Table

------------------INTERNATIONAL STATION METEOROLOGICAL CLIMATE SUMMARY-------------------

:STA 722280 | KBHM | BIRMINGHAM FAA AP ,AL,US
:LAT 33 34N :LONG 086 45W :ELEV 620(ft) 00191(m) :TYPE NOAA SMOS V3 09121994
37 - STATION CLIMATIC SUMMARY

POR: (HOURLY): 1948-1990

	TEMPERATURE (DEG F) MEANS			EXTREME		PRECIPITATION (INCHES) (^) PRECIP.				SNOWFALL (@)			REL HUM PERCENT (LST)		VAP PR IN. HG.	DEW PT. (F)	PR ALT FT. $	WIND (KTS) PREVAIL			SKY CVR +	MEAN NO. OF DAYS WITH (&) PRECIP. INCHES		SNOW-FALL (")		TH STM	FOG *	TEMP (DEG F)			
	MAX	MIN	AVG	MAX	MIN	MEAN	MAX	MIN	24H MAX	MEAN	MAX	24H MAX	AM 06	PM 15				DIR	SPD	MAX GST		>= .01	>= .50	>= .10	>= 1.5			MAX >= 65	MAX >= 50	MIN <= 32	MIN <= 0
JAN	53	33	43	81	-6	5.1	11.0	1.1	4.1	1	7	5	81	57	.19	33	100	N	8	57	OVR	11	4	1	#	2	15	6	20	16	#
FEB	58	36	47	83	3	4.9	17.7	1.1	5.3	T	2	2	80	52	.20	35	105	N	8	53	OVR	10	3	#	#	2	13	9	21	12	0
MAR	66	42	54	89	11	6.1	15.8	1.7	6.9	T	2	2	80	47	.25	41	105	S	9	60	OVR	11	4	#	#	4	13	18	29	6	0
APR	75	50	63	92	26	4.7	13.8	.4	4.6	T	5	5	83	45	.34	49	100	S	9	62	OVR	9	3	#	#	5	11	26	30	1	0
MAY	82	58	70	99	36	4.4	11.1	1.1	3.8	0	0	0	85	50	.49	58	90	S	8	77	OVR	10	3	0	0	7	13	31	31	0	0
JUN	88	66	77	102	42	3.7	8.4	.7	3.8	0	0	0	85	53	.63	65	80	NE	5	51	SCT	9	2	0	0	8	12	30	30	0	0
JUL	90	70	80	106	51	5.2	13.7	.3	5.5	0	0	0	87	57	.72	69	75	NE	5	53	BRK	12	4	0	0	12	14	31	31	0	0
AUG	90	69	80	103	53	3.8	10.8	.4	3.3	0	0	0	89	55	.70	68	75	NE	5	57	SCT	10	3	0	0	9	14	31	31	0	0
SEP	84	63	74	100	37	4.0	10.4	T	3.7	0	0	0	87	54	.57	63	80	E	7	45	CLR	8	2	0	0	4	13	30	30	0	0
OCT	75	51	63	94	27	2.8	7.5	.1	3.5	0	0	0	86	49	.38	51	85	NE	5	37	CLR	6	2	0	0	1	14	28	31	1	0
NOV	64	41	53	84	5	4.2	15.3	.4	4.4	T	1	1	84	51	.27	42	95	N	8	57	OVR	9	3	#	0	2	13	16	27	7	0
DEC	56	35	46	80	1	4.9	14.0	.8	4.5	T	8	8	81	56	.21	36	95	N	8	46	OVR	11	3	#	#	1	14	7	23	14	0
ANN	73	51	63	106	-6	53.6	76.5	40.6	6.9	1	9	8	84	52	.38	51	95	N	7	77	OVR	116	36	3	2	57	159	261	333	57	#
POR	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	11	43	43	43	43	43	43	43	43	43	43	43

T = TRACE AMOUNTS (< .05 < .5 INCHES
# = MEAN NO. DAYS < .5 DAYS
$ = PRESSURE ALTITUDE IN TENS OF FEET (I.E. 50 = 500 FEET)
@ = NAVY STATIONS REPORT HAIL AS SNOWFALL; ALSO NWS FROM JULY,1948 - DEC.,1955
+ = THE PREDOMINANT SKY CONDITION
* = VISIBILITY IS NOT CONSIDERED
& = ANN TOTALS MAY NOT EQUAL SUM OF MONTHLY VALUES DUE TO ROUNDING
^ = 24 HR MAX PRECIP AND SNOWFALL ARE DAILY TOTALS (MID-NIGHT TO MID-NIGHT)
I = EXCESSIVE MISSING DATA - VALUE NOT COMPUTED
" = INCHES

Table 3. Sample Temperature Frequency Table

------------------INTERNATIONAL STATION METEOROLOGICAL CLIMATE SUMMARY-------------------
:STA 722280 | KBHM | BIRMINGHAM FAA AP ,AL,US
:LAT 33 34N :LONG 086 45W :ELEV 620(ft) 00191(m) :TYPE NOAA SMOS V3 09121994
3 - Percent Frequency WET BULB TEMPERATURE DEPRESSION (DEG F)

JUL

DRY-BULB (Deg F)	0	1-2	3-4	5-6	7-8	9-10	11-12	13-14	15-16	17-18	19-20	21-22	23-24	25-26	27-28	29-30	> 30	TOTAL Dry/Wet	TOTAL Dry	TOTAL Wet	OBS Dew
>=105	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	4	4	0	0
>=103	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	*	5	5	0	0
>=101	0	0	0	0	0	0	0	0	0	0	0	*	.1	*	*	0	0	16	16	0	0
>=99	0	0	0	0	0	0	0	0	0	0	*	*	.1	.1	*	*	*	30	30	0	0
>=97	0	0	0	0	0	0	0	0	0	*	.2	.2	.1	*	*	0	0	57	58	0	0
>=95	0	0	0	0	0	0	0	*	.1	.3	.4	.3	.1	*	0	0	0	127	127	0	0
>=93	0	0	0	0	0	0	0	.2	.8	.7	.4	.2	*	0	*	0	0	250	250	0	0
>=91	0	0	0	0	0	*	.2	1.0	1.5	.8	.4	.1	*	0	0	0	0	420	420	0	0
>=89	0	0	0	0	*	.2	1.1	1.7	1.2	.5	.3	.1	*	0	0	0	0	547	547	0	0
>=87	0	0	0	0	.1	1.2	2.1	1.7	.7	.3	.1	*	0	0	0	0	0	658	659	0	0
>=85	0	0	*	.1	.9	2.6	2.1	.7	.4	.2	.1	*	0	0	0	0	0	749	749	0	0
>=83	0	0	*	.6	1.8	1.8	.8	.5	.3	.1	*	0	0	0	0	0	0	644	644	0	0
>=81	0	*	.3	2.0	2.5	1.3	.5	.3	.2	.1	*	0	0	0	0	0	0	761	762	13	0
>=79	0	.2	1.4	2.8	1.7	.6	.2	.1	*	*	0	0	0	0	0	0	0	755	755	182	2
>=77	*	.7	3.5	2.8	1.0	.4	.2	.1	*	0	0	0	0	0	0	0	0	920	920	922	52
>=75	.1	3.2	5.6	2.1	.5	.2	*	*	0	0	0	0	0	0	0	0	0	1260	1260	1854	331
>=73	.4	6.0	4.7	1.1	.3	.1	*	0	0	0	0	0	0	0	0	0	0	1350	1352	2322	1391
>=71	.6	6.0	2.9	.7	.2	.1	0	0	0	0	0	0	0	0	0	0	0	1133	1133	2313	2565
>=69	.6	2.6	1.4	.3	.1	*	0	0	0	0	0	0	0	0	0	0	0	525	525	1607	2587
>=67	.2	1.0	.6	.2	*	0	0	0	0	0	0	0	0	0	0	0	0	215	215	737	1604
>=65	.1	.5	.3	.1	0	0	0	0	0	0	0	0	0	0	0	0	0	107	107	369	811
>=63	.1	.4	.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	68	68	164	527
>=61	*	.2	.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29	29	109	347
>=59	*	.2	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19	18	39	218
>=57	0	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4	17	122
>=55	0	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5	10	63
>=53	0	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	30
>=51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	7
>=49	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
>=47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TOTAL	2.3	20.9	21.1	12.8	9.2	8.5	7.2	6.3	5.2	3.0	1.8	1.0	.4	.2	.1	*	*	10659	10664	10659	10660

* = PERCENT < .05
# = EXCESSIVE MISSING DATA - VALUE NOT COMPUTED

process will cause the curves to overlap when graphed.

As a further aid in curve comparison and to facilitate processing, the amount of frequency levels in the cumulative frequency curves was standardized. An investigation indicated that 21 standardized frequency levels can adequately and accurately approximate the temperature frequency curve for any station. The selected frequency levels were: 0, 0.001, 0.005, 0.01, 0.03, 0.05, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 0.95, 0.97, 0.99, 0.995, 0.999, and 1.0. For prediction purposes, there are 19 levels to be concerned with, inasmuch as levels 0 and 100 represent the asymptotes -- the absolute minimum temperature and absolute maximum temperatures, respectively. In tests, the differences between the actual and the standardized curves were approximately ±0.3°F, with these differences most often appearing at the curves' inflection points. This process, then, created 12 monthly data sets of standardized-normalized monthly temperature frequency distributions.

Model Building and Validation Data Sets

It was decided to divide the 278 stations into a model and a validation data set. The number of stations in each data set was arbitrarily set at 200 for model building and 78 for validation. To perform the operation of selecting which 78 stations would comprise the validation data set, a stratified random sample was drawn from the data. Stratification was based on 10-degree bands of latitude. Stations were randomly selected using a computer-based random number generator. Based on the percent of the total number of stations in each of these 10-degree bands, the equivalent percent of the 78 stations required for the validation data set were extracted. For example, if 10 percent of the total number of stations were in the 20° to 30° latitude range, then 10 percent of 78 stations would be randomly extracted (0.10 x 78 = 7.8 or 8 stations). Data from the monthly attribute and the monthly normalized-standardized temperature frequency data sets for the validation stations were then removed to create the validation data sets. At this point, all the monthly data sets were ready for input into discriminant analysis. Prior to the formal model runs, a number of test runs were performed with the data for a particular month, to help refine the overall analysis method, and the behavior of the data was examined to ensure that all the data sets had been correctly processed.

Refinement of the Procedure and Test Runs

The basic approach in processing the data consisted of the following activities. Prior to the model runs, each of the data sets were imported into standard spreadsheet software and formatted to allow acceptance by the BMDP software as a 'Port' file.

The initial procedures, after data import into BMDP, involved the following steps:

1) The first step involved performing cluster analysis on the attribute data to generate an artificial grouping variable to be used in the subsequent discriminant analysis. Cluster analysis was performed using Version 7.01 of BMDP software. The software program was "K-Means Clustering of Cases" (BMDP-KM, 1992b). This is a PC version of the BMDP software currently running on mainframes.

KM clustering is a nonhierarchical classification method that is designed to place samples into a single classification of 'k' clusters so that the relationships between the clusters is revealed. Sometimes referred to as iterative relocation (Gordon, 1981; Anderberg, 1973), it attempts to identify any possible tendency for data to 'clump' together to form groups (James, 1985). This classification is internally based; that is, it is not dependent on *a priori* knowledge about relationships between the samples. In other words, the data are allowed to dictate the patterns of the clusters found. KM clustering begins with one 'grand cluster' containing all the samples. The programming repeatedly splits a cluster into two and iteratively reallocates cases until it reaches the 'k' number of clusters. Cases are iteratively relocated to the cluster whose centroid is closest in Euclidean distance to the case. After each iteration, the centroids are recalculated for the cluster receiving the new case and the cluster losing the case (Johnson and Wichern, 1992). Similar to discriminant analysis, cluster analysis seeks to minimize the within-cluster variance and maximize the between-cluster variance.

After selection of the number of desired clusters, cluster analysis was performed on the attribute data for a specific month, and then each station's cluster assignment was manually transferred to the attribute data set to serve as an artificial grouping variable during the subsequent discriminant analysis runs. Since the units of measure for the attribute variables differed greatly, the cluster analysis programming was instructed to standardize the data to unit variance. This, in effect, gives equal weight to each variable, whatever the original unit of measurement.

2) Discriminant analysis on the attribute data set was performed using BMDP's Program 7M (BMDP-7M, 1992a). The classification matrix and the posterior probabilities of group membership were then examined for the misclassified stations. As a general rule, if a misclassified station had a posterior probability of >0.5 of belonging to another group, the misclassified station was automatically transferred. However, this was tempered by the logic of the move in terms of topographic and climatic considerations. After the group reassignments had been accomplished, discriminant analysis was performed again. Stations that had posterior probabilities < 0.5 of belonging to another group were then all transferred to the appropriate groups. The total process took, in some instances, up to eight iterations in order to make the classification matrix reach 100 percent. As stations were reassigned to groups on the basis of their posterior

probabilities, the posterior probabilities of other stations belonging to certain groups would change. When all stations had been correctly classified, the discriminant functions were extracted. Since it was desired to retain all of the attribute variables to determine which of them were important for distinguishing among groups, all of the attribute variables were forced into the discriminant analysis.

3) The new grouping variable was then transferred to the data set containing the standardized-normalized temperatures. Discriminant analysis was performed and the temperature frequency group means for each group were extracted. This is the data set that is used in developing curve-fitting equations to enable the estimation of the frequency of occurrence of an input temperature.

4) The discriminant functions, group mean normalized temperatures, and the actual station data (both attribute and standardized-normalized temperatures) were then transferred into a custom-designed program that computes the residual at each of the 19 temperature frequency levels for each station. This residual is defined as the difference between a station's actual temperature frequency curve and the mean curve of the discriminant function group to which the station was assigned. Nineteen residuals were generated for each station.

5) The observations in the validation data set were then classified using the generated discriminant functions to obtain the group membership of these stations. The residuals from both the validation and model building data sets were merged and analyzed. The station group membership for both the model building and validation data sets was then mapped.

6) The spatial patterns of the groups and the distribution of errors and their magnitude for each group were then examined. If on examination of the results, it was felt that higher accuracy could be attained, then the number of initial clusters was increased and the entire process repeated beginning with Step 1. The above six steps represent a complete run in an iterative process in which the object was to find the optimal number of clusters to maximize the accuracy.

As an initial test, January was selected as the first month to be processed. During discriminant analysis runs for January, two additional stations were removed from consideration. These sites, both U.S. Naval Air Stations, are located in Tennessee and Florida. Although both were assigned to what appeared to be a reasonable group, they exhibited errors of high magnitude (> 5°F) throughout the full range of their temperature frequency curves. Upon examination, these two stations possessed only about 2,000 temperature observations. The vast majority of stations used in this analysis had between 6,500 and 11,000 observations. It well might be that the cumulative frequency distribution was immature because of the relatively small number of observations. One of Lackey's reports (1960a) examined how the length of a station's period-of-record

(POR) affects the accuracy of temperature frequency estimation models.

At this point, 276 stations remained for analysis purposes -- 198 in the model-building data base and 78 in validation data set. No further stations were deleted from the data sets. Figures 16 and 17 show the locations for the 276 stations -- North American (261 stations) and Pacific islands (15 stations). Table 4 (Appendix A) provides a detailed listing of the 276 stations.

Prior to the subsequent mapping of the discriminant function groups, it also became apparent that there was a paucity of first-order stations for large portions of Central and Northern Canada. This is not surprising, inasmuch as the vast majority of Canadians live within 100 miles of the U.S. border and practically all of Canada's major cities also are found there. Therefore, an additional 21 second-order Canadian stations were selected to provide a more uniform coverage for Canada. The locations of these additional second-order Canadian stations appear in Figure 16 and a detailed listing appears in Table 5 (Appendix A). Attribute data for these stations were obtained and/or derived for each month from their respective climate summaries found on the ISMCS for eventual processing through the discriminant functions to determine monthly group membership.

Complete test runs for 12, 18, 24, 28, 32, and 40 clusters again were performed in their entirety for January. When 36 clusters were selected, the topographic/climatic patterns became unexplainable. Among other things, Rochester, MN was grouped with Dallas, TX and about three-quarters of the generated predicted temperatures for Rochester were different by up to 6°F from actual data. When analysis on 40 clusters was performed, many singularities appeared (clusters with only one station assigned to them). When 35 clusters were processed, the patterns and singularities exhibited in the runs of 36 and 40 clusters disappeared. Predictive accuracy of several of these January runs is shown in Figure 18. As is shown, predictive accuracy increased noticeably from 28 clusters to 35 clusters, but did not increase appreciably as additional clusters above 35 were added.

Subsequent months were then processed in similar fashion, always seeking to maximize accuracy and minimize the number of clusters. A total of 5,244 individual levels were predicted for each month (19 levels x 276 stations) for the combined model building and validation data sets (62,928 annual total). In order to evaluate how well the model performed, some error criterion had to be established. Error, in this context, is a difference between the group mean temperature curve and a station curve that exceeds 2.0°C at any of the 19 frequency levels. Although the value 2.0°C is somewhat arbitrary, it is close to the average composite error value that Tattleman and Kantor (1977) obtained in their generation of prediction models for the coldest and warmest months.

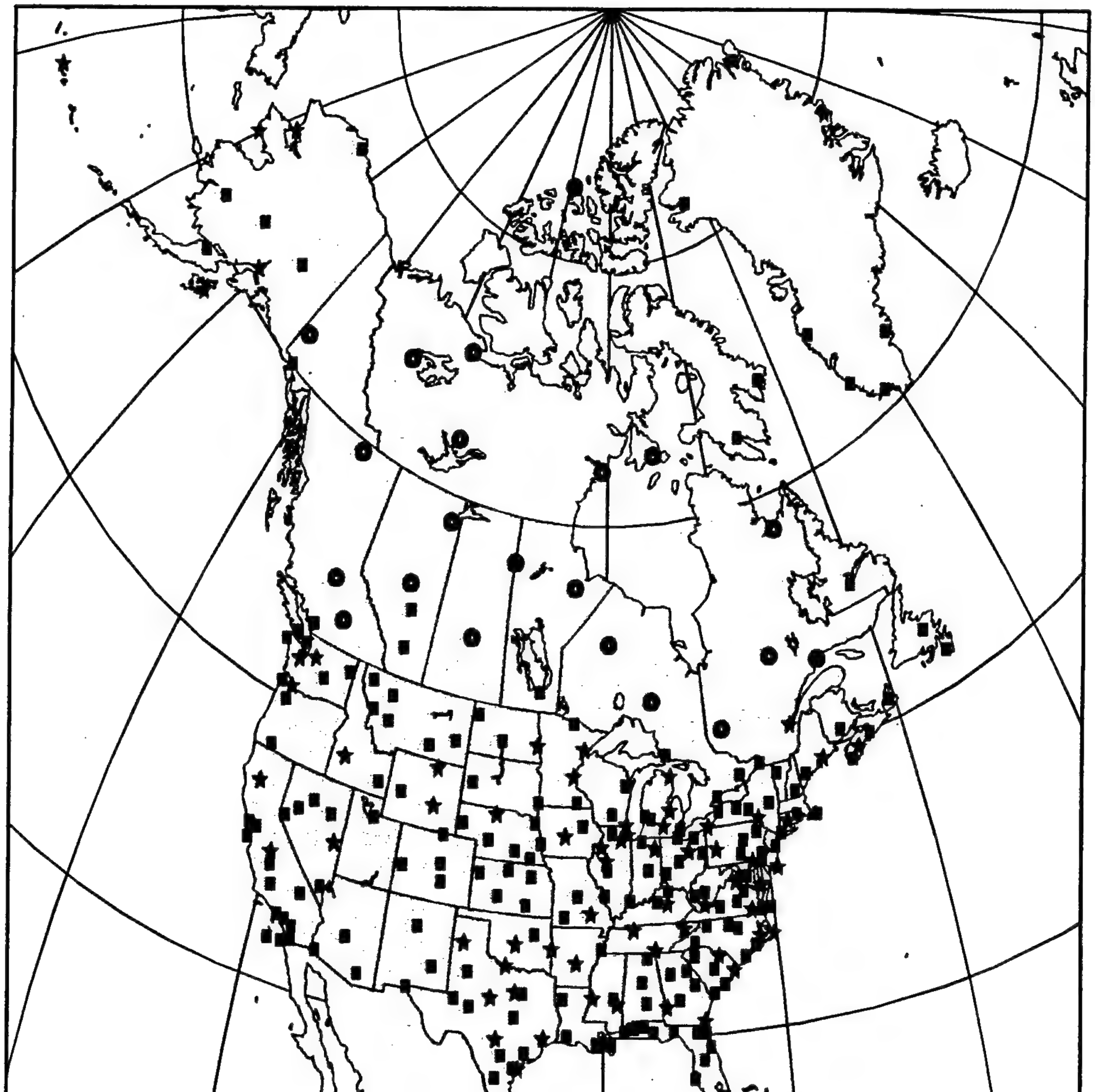

FIGURE 16. STATION LOCATION MAP -- NORTH AMERICA

■ = MODEL BUILDING STATIONS

★ = VALIDATION STATIONS

● = CANADIAN STATIONS (FOR MAPPING ONLY)

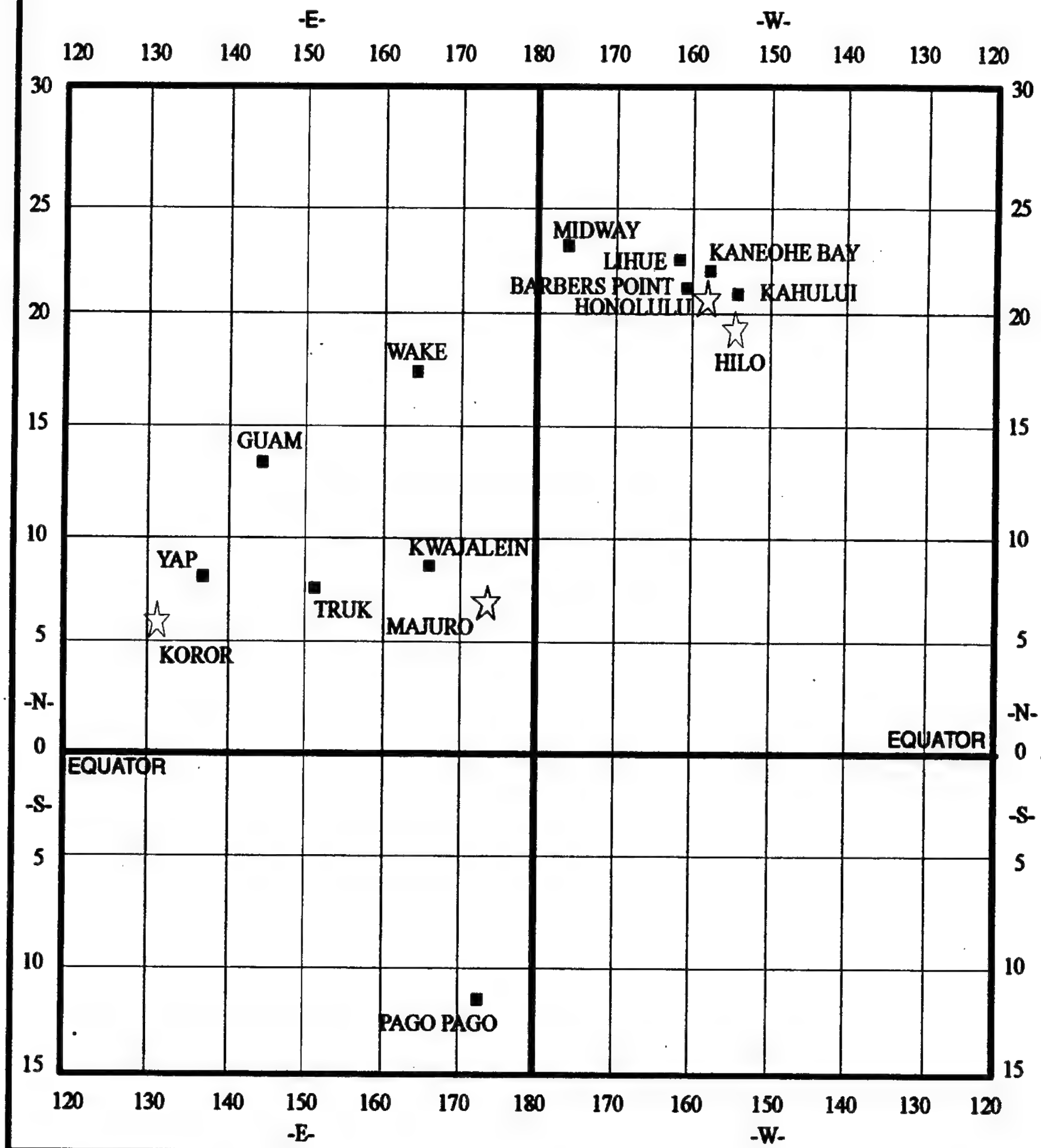

FIGURE 17. STATION LOCATION MAP -- PACIFIC

■ = MODEL BUILDING STATIONS

☆ = VALIDATION STATIONS

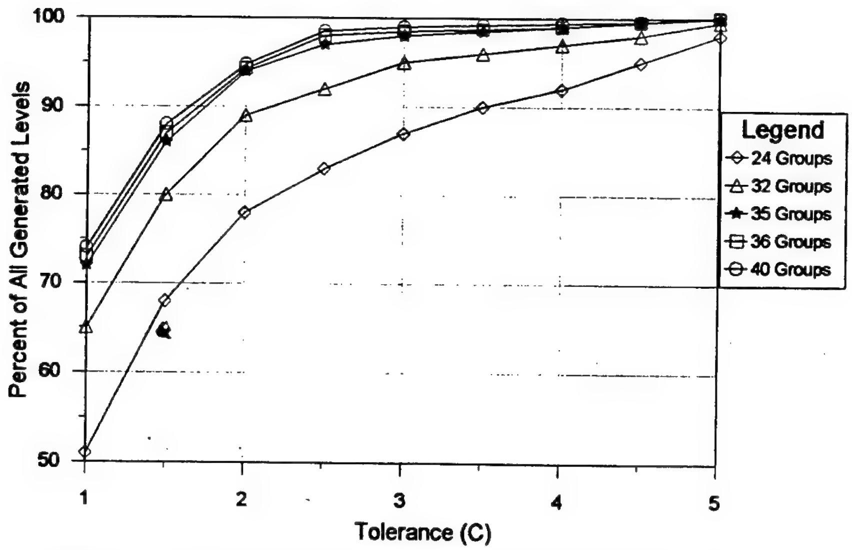

Figure 18. Predictive Accuracy for Various Cluster Numbers
for Selected January Runs

Discriminant Analysis Output

A number of types of data were extracted from the discriminant analysis runs and are presented in the individual monthly sections. Three primary data sets are group means for the attribute variables, discriminant functions, and, group mean normalized temperatures.

The group means for the attribute variables aid in the discussion of the rationale for group differentiation. They can show, for example, the variables that are exhibiting the greatest differences between several adjacent groups, and thus, may provide an indication as rationale behind the breakup of a geographic region into small groups.

The discriminant functions are required to assign a station to a specific group. The function itself consists of a constant and 8 coefficients and takes the form

$$\text{Function value} = b_1 + b_2\text{lat} + b_3\text{elev} + b_4\text{P/E} + b_5\text{K} + b_6\text{mrange} + b_7\text{drange} + b_8\text{nmax} + b_9\text{ nmin} \qquad (9)$$

where b_1 is a constant, b_2 through b_9 are the individual coefficients, lat is station latitude in decimal degrees, elev is station elevation in feet, P/E is Precipitation Effectiveness Index, K is Conrad's Continentality Index, mrange is monthly temperature range (°F), drange is

daily temperature range (°F), nmax is normalized mean daily maximum temperature, and, nmin is normalized mean daily minimum temperature. When a station's attribute variables are iterated through all of the discriminant functions for a month, the station is assigned to the group having the highest discriminant function value.

The group mean normalized temperatures for each month are the values that were employed in the generation of the curve-fitting equations. In order to allow the computation of the frequency of occurrence of an input temperature, every group mean normalized temperature distribution (a total of 363 for all 12 months) must have an equation.

Curve Fitting

For curve-fitting purposes, the first equation investigated was the logistic function. The normalized cumulative temperature frequency distributions are sigmoid shaped and closely resemble the curve generated by the logistic function (Hastings and Peacock, 1975). This model has a number of applications within geography and other sciences. For example, Abler, Adams and Gould (1971) illustrated how the diffusion of inventions in society follows the logistic model quite closely. Wilson and Douglas (1969) showed how tree growth can be successfully modeled by the logistic function. Cole and King (1968) used a logistic function with U.S. population growth data.

The logistic function has the form

$$y = 1 / (1 + e^{(a-bt)}) + \varepsilon \qquad (10)$$

where a is the y intercept, b is the slope, t is the input temperature, e is the base of the natural logarithms with an approximate value of 2.7183, and ε is the error term. The software of choice was StatMost (DataMost, 1994). StatMost offers a nonlinear regression/curve-fitting routine. After input of the model (Equation 10), the software requires, in this case, that initial estimates of a and b be provided. In order to provide initial estimates of a and b for the iterative process required to derive the above equation, linear regressions were first performed for all 363 mean, normalized temperature distributions. These computed a and b values then were placed into the software routine to compute the best values of a and b for the logistic function. Figure 19 shows the fit of the logistic function to a typical group mean normalized temperature frequency curve. The fit is quite good.

An examination of the results from logistic regression indicated that, in some cases, differences (residuals) between the actual data and those values derived from the function either under or over estimated the frequency of occurrence by 4 to 6 percent. Since one of the purposes in generating the equations is to permit the eventual estimation of the frequency of occurrence of an input temperature, it was decided to increase the accuracy by examining the error term (the 'ε' term in Equation 10). A polynomial expression was fit to the residuals from the logistic regression. Logistic functions and accompanying error polynomials were then generated for all the groups in January and February. Unfortunately, there was the recurring problem of trying to fit the polynomial function to the residuals from the logistic regression. Figure 20 shows the polynomial fit to the residuals from the previous example. It can be seen that the residual pattern is such that the polynomial function is not adequately representative. In addition, an examination of the P-values for the coefficients for the 2 months showed that, in all cases, each polynomial had between one and four coefficients with values greater than 0.05 -- values less than 0.05 indicate statistically significant non-zero coefficients.

Other curve-fitting forms were subsequently tried. One combination that showed promise consisted of a simple linear form with the accompanying polynomial error term. The equation used took the form

$$y = a + bt + \varepsilon \qquad (11)$$

where a is the y intercept, b is the slope, t is the normalized temperature, and ε is the polynomial error term of the form

$$y = a + bt + ct^2 + dt^3 + et^4 \ldots + xt^n \qquad (12)$$

where a is the y intercept, b through x are the coefficients and t is the normalized temperature. Figure 21 shows the linear output from the same group as in the above example and Figure 22 shows the polynomial fit to the residuals from the linear regression. It can be seen that the polynomial function fit is quite good. All of the generated coefficients from this polynomial regression were statistically significant at the 0.05 level. The linear-polynomial combination was then performed for all 363 groups. However, about 20 percent of all the generated linear-polynomial combinations yielded frequency prediction estimates with errors greater than 2 percent. A few of these errors were on the order of 5 to 6 percent. It was decided to reinvestigate the curve-fitting models in an effort to enhance their accuracy.

It was finally decided to split the frequency distribution into two parts at the 50th percentile frequency and generate polynomials for the individual upper and lower portions

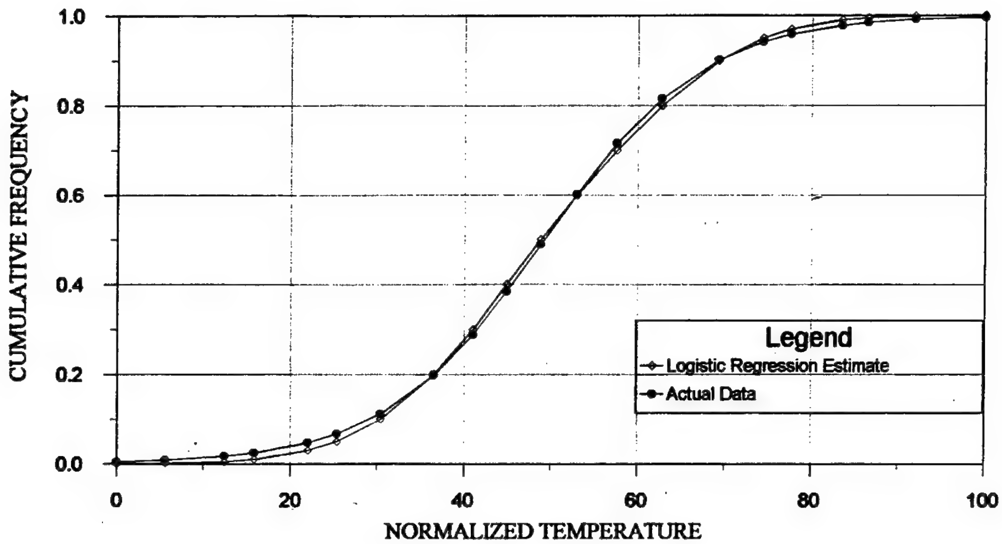

Figure 19. Logistic Regression for February: Group 31

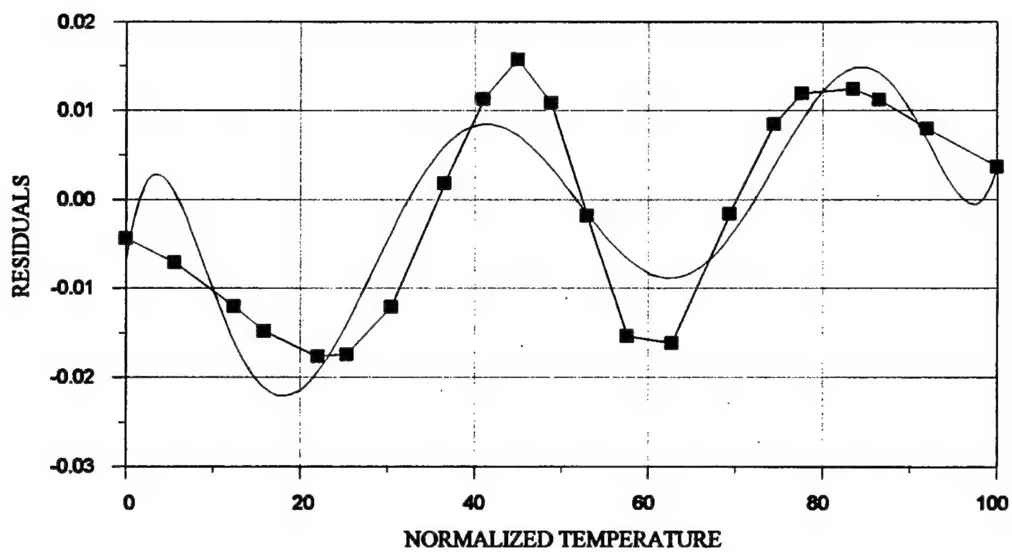

Figure 20. Polynomial Fit to Residuals from Logistic Regression For February: Group 31

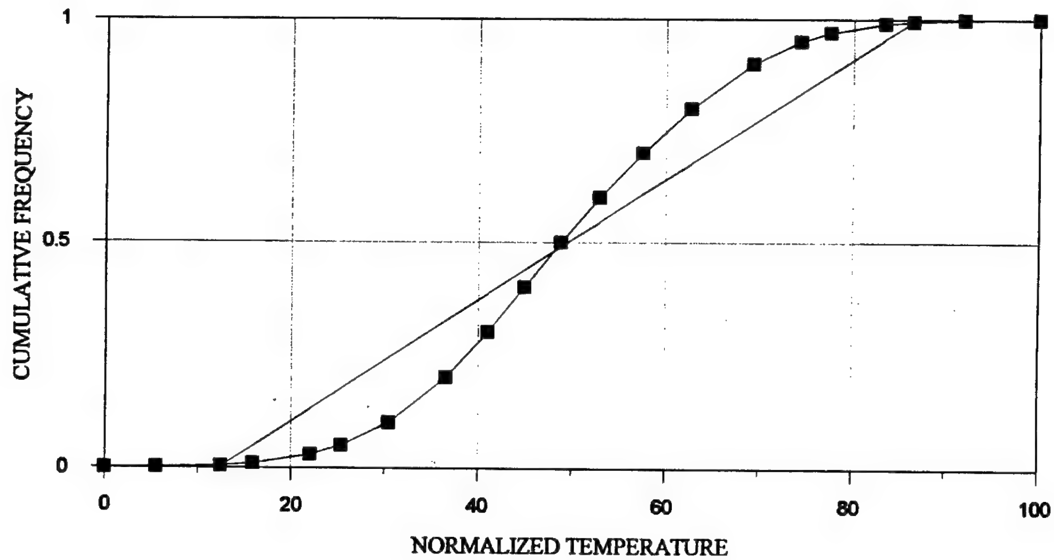

Figure 21. Linear Regression for February: Group 31

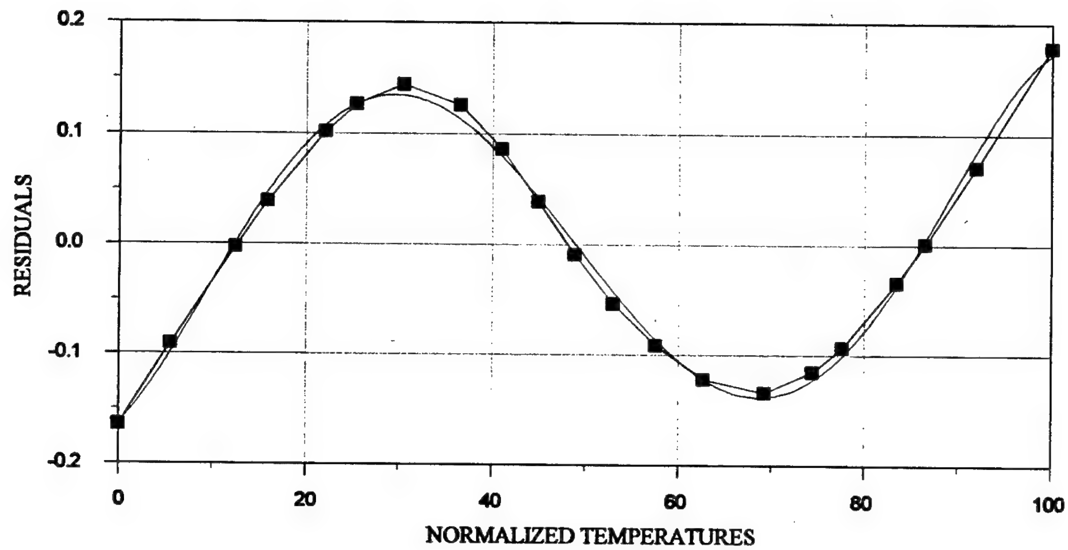

Figure 22. Polynomial Fit to Residuals from Linear Regression
for February: Group 31

of each of the curves. The equation for each portion of the curve took the form

$$y = a + bt + ct^2 \ldots + xt^n \qquad (13)$$

where a is the y intercept, b through x are the coefficients and t is the normalized temperature. This resulted in the generation of 726 polynomials (2 x 363). Approximately 90 percent of the generated polynomials were third-term, with the remaining 10 percent requiring a fourth-term expression. In regard to the predicted frequency of occurrence, the average absolute error was 0.006 and the maximum absolute error was 0.02. This is a noticeable increase in accuracy over both the logistic/polynomial and the linear/polynomial combinations. Figure 23 and 24 show the curve-fitting results for the same group as in the previous two examples.

Summary

The method to approximate the frequency of occurrence of a temperature at any location is straightforward. The procedure involves the following steps:

1) After selection of the station and the desired month, extract and/or derive the eight required topographic/climatic attribute variables. Latitude is converted to decimal degrees (e.g., 34° 45' = 34.75°). The unit of measure for the elevation is feet. Precipitation Effectiveness (P/E) is computed using Equation 6. Continentality is computed using Equation 7. Monthly range (°F) is the difference between the absolute maximum and absolute minimum temperatures. Daily range (°F) is the difference between the mean daily maximum and mean daily minimum temperatures. The normalized mean daily maximum and mean daily minimum temperatures are generated by using Equation 8.

2) Select the appropriate monthly table of discriminant function values. Iterate the 8 topographic/climatic attribute variables through all of the equations. The station is assigned to the group having the highest discriminant function value. Manually, this process is quite tedious and thus would lend itself to automation.

3) Normalize the desired input temperature using Equation 8. From the appropriate set of group curve-fitting equations select the appropriate equation and solve the polynomial. Accuracy measures for the generated frequency of occurrence value are provided for each equation. The appropriate monthly probability table then can be used to assess the general goodness of the group to which the station was assigned and to assess

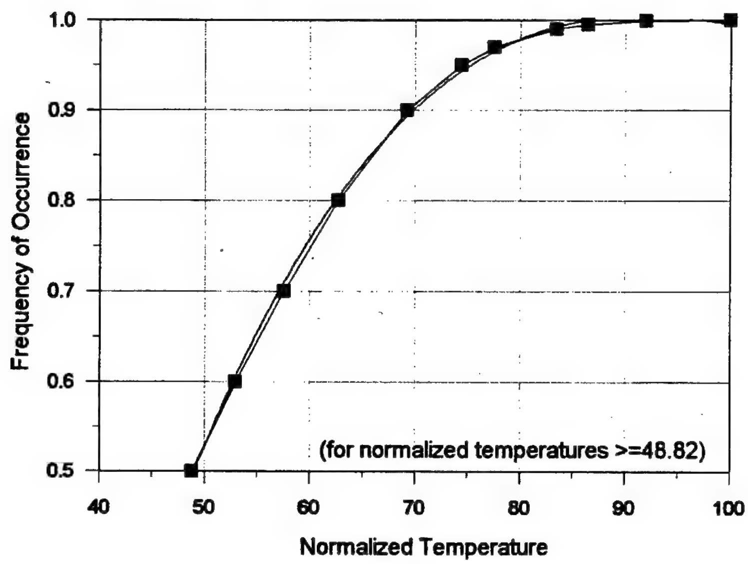

Figure 23. Polynomial Fit (3rd term) for Upper Half of Cumulative Frequency Curve for February: Group 31

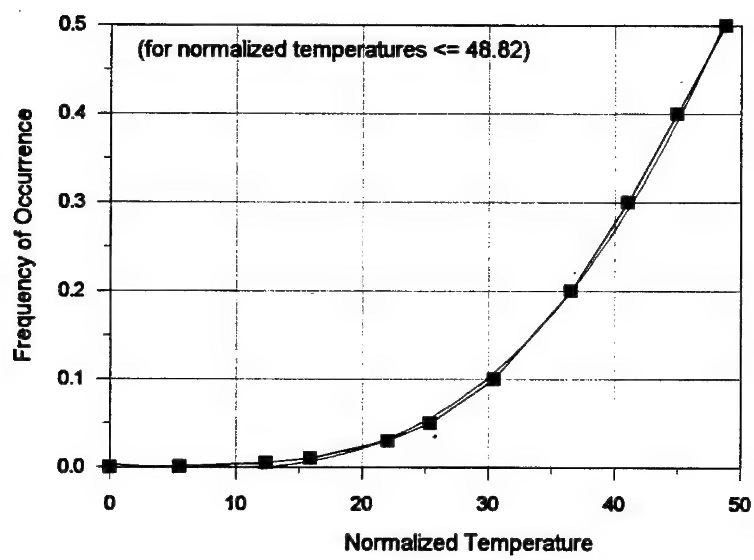

Figure 24. Polynomial Fit (3rd term) for Lower Half of Cumulative Frequency Curve for February: Group 31

the overall accuracy at proximate frequency levels.

Therefore, the procedure which has been finalized, enables a station's monthly frequency of occurrence of temperature to be estimated based on selected topographic and climatic attributes. The next section presents the results of the analysis for all 12 months.

DISCUSSION OF RESULTS

The results of the analysis are presented in this section. The discussion will be on a monthly basis, grouped by season of the year. After the analysis of the geographic patterns of the discriminant function groups, the nature and characteristics of the generated residuals will be treated. This will be followed by an examination of the patterns of the temperature frequency curves.

The maps that illustrate the locations of the discriminant function groups were cartographically compiled by hand. The group boundaries are, in essence, mere generalizations as their location is based on an extremely limited number of randomly spaced stations that were used in model development. For many areas, station density is sufficient and topography fairly uniform so that the group boundaries are relatively indicative of their actual location. Such would be the case in the southeastern portions of the U.S. However, as station density decreases and/or the topography becomes more diverse, the actual location of the group boundaries becomes increasingly fuzzy.

This is especially true in areas of wildly diverse topography such as the western portions of North America. Besides the horizontal changes in the temperature environment, the vertical changes have to be considered. In this region, elevation can change dramatically and abruptly over short horizontal distances. Unfortunately, climatic station density in this region is quite sparse. Group characteristics, therefore, may be based on only a handful of stations in an area covering many tens-of-thousands of square miles and cannot be expected to be representative of all the thermal environments contained within the group's boundaries. This is in line with the findings of Doesken and McKee (1983) when they concluded that their model worked fairly well for a very small geographic area in Colorado, but would probably not be applicable elsewhere.

Heightened generalization and fuzziness of the group boundaries also would apply to areas such as Canada and Alaska, where station density is extremely poor -- Alaska has a station density of roughly one station to over 100,000mi^2. For other geographic regions, such as the Canadian Rockies and in vast expanses of northern Canada, no stations were found that could be employed in model development. Hence, there exist regions, such as those just described, that although they fall within a specific group, probably have different temperature frequency curves than the group mean curve representing the group into which they were placed.

Likewise, the climate of certain islands in the tropical Pacific can be more diverse than would, at first glance, seem possible. The 15 Pacific island stations found in the model building and validation data bases represent all the stations in this geographic area

that possessed the requisite data tables. They are all low elevation and primarily coastal locations. However, certain mountains found in the Hawaiian Islands, for example, possess elevations up to nearly 14,000 feet, thus encompass climates ranging from tropic to sub-Arctic (Armstrong, 1973). Also, windward and leeward locations and places with diverse topography on these islands can exhibit drastic differences in their moisture environments and thus, their thermal environments. For example, average annual rainfall in some locations in Hawaii exceeds 400 inches, whereas at other sites, only tens of miles away, barely 10 inches per year occurs. Therefore, the stations used in model development may not represent the totality of thermal environments found on these islands. This same logic also applies to the island stations found in the Caribbean. Hence, the discriminant function group boundary lines should be viewed with caution, especially in the geographic areas just outlined.

Likewise, maps are presented that show the group skewness based on the group mean temperature frequency curve. It is somewhat difficult to discern how representative a group mean curve skewness is of the skewness of the curves of the individual stations within the group. One or two highly skewed stations could, in effect, place the group in a skewness category that is not representative of the bulk of the stations found in that particular group. The skewness values, therefore, should be regarded as general in nature, although groups that exhibit either exceptionally high positive or negative skewness will be rationalized in terms of various climatic variables impacting their locations at different times of the year.

Prior to a detailed discussion of the monthly results, a short description of some of the overall results for all the months will be presented. This should provide the reader with an appreciation of the general month-to-month and seasonal characteristics and a broad indication of model performance.

Discriminant Function Groups

A total of 363 temperature frequency groups were generated for the 12 months. Figure 25 shows the number of groups that were found to maximize the accuracy for each of the months while maintaining fairly logical topographic and climatic patterns. It can be readily seen that more groups are required for the winter months and fewer for the summer. This appears logical inasmuch as compared to summer, winter has more thermal contrasts and much steeper temperature gradients across the geographic study area. For example, while there is only about a 20°F difference in mean temperatures between central Florida and northern Minnesota during July, the difference in January is over 60°F (Environmental Data Service, 1968; Baldwin, 1973).

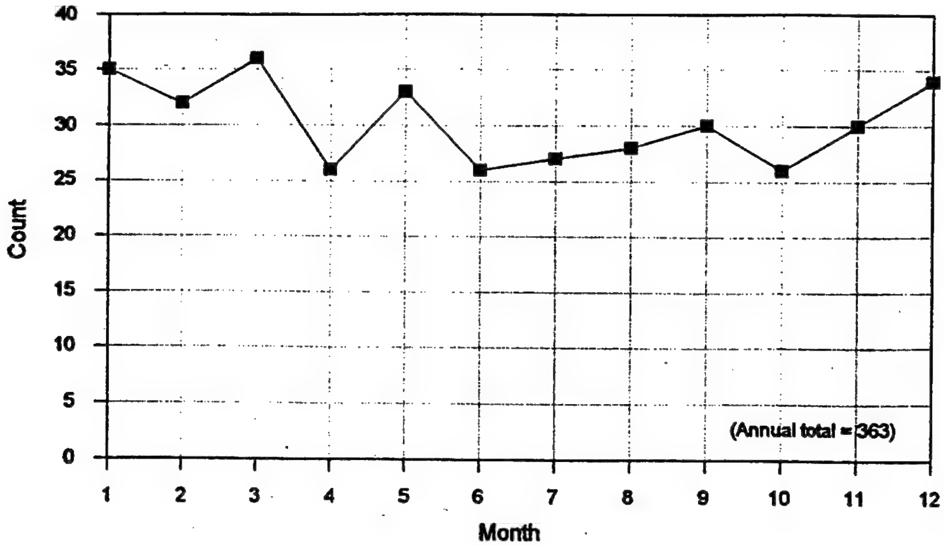

Figure 25. Number of Discriminant Function Groups by Month

Eigenvalues

Within discriminant analysis, eigenvalues can provide an indication of the discriminating power of the generated functions. Table 6 shows the monthly eigenvalues of the discriminant analysis runs for the attribute variables. Table 7 translates these eigenvalues into the cumulative proportion of total dispersion accounted for by the eigenvalues. Table 8 lists the attribute variables from the discriminant analysis Summary Tables in order of their "F" statistic magnitude. The "F" statistic may be used to assess the relative importance among the candidate variables in terms of their contribution to the discrimination between groups. Several observations on these tables are as follows: 1) there is a general consistency in magnitude of the eigenvalues from month to month; 2) the first four eigenvalues contribute most to the discriminating power of the functions, explaining approximately 85-90 percent of the dispersion; 3) latitude, elevation, continentality and Precipitation Effectiveness (P/E) Index are the dominant variables that best help discriminate between groups during each of the months; and, 4) monthly range is the weakest variable and contributes very little to the discriminating power of the functions.

Skewness

Although the geographic patterns of skewness will be treated in the monthly discussions, an examination of its month-to-month progression is appropriate at this point. Both Court (1951) and Clark (1954) use the element skewness to aid in the regionalization of temperature frequency distributions. Court (1951) emphasized that the

Table 6. Eigenvalues for Attribute Data Discriminant Analysis

MONTH	1	2	3	4	5	6	7	8
JANUARY	33.3	23.9	9.5	8.8	7.4	3.1	2.5	1.3
FEBRUARY	35.6	14.8	9.4	6.6	5.7	3.6	1.4	0.6
MARCH	30.6	12.9	10.9	8.8	3.5	2.8	1.6	0.9
APRIL	26.2	16.6	11.7	6.6	4.4	3.0	1.8	0.8
MAY	26.2	21.7	14.4	8.7	6.0	4.1	2.0	1.3
JUNE	38.1	12.7	9.4	5.4	3.6	1.3	0.9	0.3
JULY	26.1	13.3	8.2	5.4	3.0	2.4	1.5	1.0
AUGUST	25.9	16.7	9.9	5.5	3.8	2.0	1.3	1.1
SEPTEMBER	29.8	17.9	12.8	7.5	6.1	3.0	1.8	0.8
OCTOBER	32.1	17.4	10.7	6.7	4.8	3.4	1.3	1.2
NOVEMBER	33.0	18.1	12.6	5.3	4.5	3.2	2.0	1.2
DECEMBER	32.1	19.0	11.0	9.2	5.4	4.5	2.3	1.1

Table 7. Cumulative Proportion of Total Dispersion for Attribute Data Eigenvalues

MONTH	1	2	3	4	5	6	7	8
JANUARY	0.37	0.64	0.74	0.84	0.92	0.96	0.99	1.00
FEBRUARY	0.46	0.65	0.77	0.86	0.93	0.98	0.99	1.00
MARCH	0.43	0.60	0.76	0.87	0.93	0.97	0.99	1.00
APRIL	0.37	0.60	0.77	0.86	0.92	0.96	0.99	1.00
MAY	0.31	0.57	0.74	0.84	0.91	0.96	0.98	1.00
JUNE	0.53	0.71	0.84	0.91	0.97	0.98	0.99	1.00
JULY	0.43	0.65	0.78	0.87	0.92	0.96	0.98	1.00
AUGUST	0.39	0.64	0.79	0.88	0.93	0.96	0.98	1.00
SEPTEMBER	0.37	0.60	0.76	0.85	0.93	0.97	0.99	1.00
OCTOBER	0.41	0.64	0.78	0.86	0.92	0.97	0.98	1.00
NOVEMBER	0.41	0.64	0.80	0.86	0.92	0.96	0.99	1.00
DECEMBER	0.38	0.60	0.73	0.84	0.91	0.96	0.99	1.00

Table 8. Predictor Variables Sorted by Magnitude of "F" Statistic

MONTH	1	2	3	4	5	6	7	8
JANUARY	CONT	ELEV	LAT	P/E	NMIN	NMAX	DR	MR
FEBRUARY	CONT	ELEV	LAT	P/E	NMIN	DR	NMAX	MR
MARCH	P/E	CONT	LAT	ELEV	NMAX	MR	DR	NMIN
APRIL	CONT	LAT	ELEV	P/E	NMAX	NMIN	DR	MR
MAY	LAT	ELEV	CONT	P/E	NMIN	DR	NMAX	MR
JUNE	ELEV	CONT	LAT	P/E	NMAX	DR	NMIN	MR
JULY	LAT	ELEV	CONT	P/E	DR	NMAX	NMIN	MR
AUGUST	ELEV	LAT	CONT	P/E	DR	NMAX	NMIN	MR
SEPTEMBER	ELEV	LAT	CONT	P/E	NMAX	DR	NMIN	MR
OCTOBER	CONT	LAT	ELEV	P/E	NMAX	DR	NMIN	MR
NOVEMBER	LAT	CONT	P/E	ELEV	NMIN	DR	NMAX	MR
DECEMBER	ELEV	LAT	CONT	P/E	NMIN	DR	NMAX	MR

**ATTRIBUTE VARIABLES

LAT -LATITUDE ELEV - ELEVATION P/E - PRECIPITATION EFFECTIVENESS INDEX

CONT - CONTINENTALITY MR - MONTHLY TEMP RANGE DR - DAILY TEMP RANGE

NMAX - NORMALIZED MEAN MAXIMUM TEMP NMIN - NORMALIZED MEAN MINIMUM TEMP

skewness of the temperature frequency distributions in many geographic areas is indicative of such attributes as prevailing air masses, proximity to water bodies, etc. Figure 26 contains the monthly composite skewness of the temperature frequency groups. This composite represents the average skewness for all of the temperature frequency groups for each month. The curve shows a negative skewness for the months of November through March and a positive skewness from April to October.

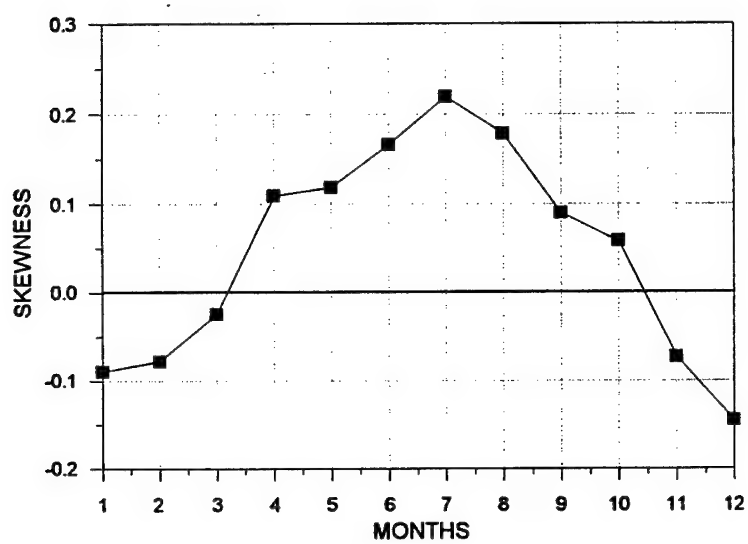

Figure 26. Skewness for Monthly Composite Normalized Temperature Frequency Curves

The distributions are, in essence, skewed in the direction of the prevalent extremes for the month. During the colder months, more of the individual group distributions tend to be skewed to the left (negative) toward the colder temperatures. Conversely, during the warmer months, there is a rightward (positive) skew towards the higher temperatures. This corroborates Court's findings (1951) that showed that temperature distributions are generally more negative in winter and positive in summer. During the transition seasons, which do not contain the annual extremes, the skewness is somewhat less. Nonetheless, the month-to-month pattern is quite pronounced.

Kurtosis

Like skewness, both Court (1951) and Clark (1954) used kurtosis to assist in placing stations into temperature frequency groups. Figure 27 shows the monthly composite kurtosis for the temperature frequency groups. Although the pattern is not as pronounced as that for skewness, it does show a pattern of flatter (more platykurtic) distributions in the colder months and slightly more peaked distributions in the warmer months. This would appear to be a function of the monthly range. As mentioned earlier, monthly ranges tend to be greater (longer tails in the distributions) during the colder months of the year. For example, January's composite monthly temperature range in this study is 79.3°F, whereas July's composite range is only 53.1°F.

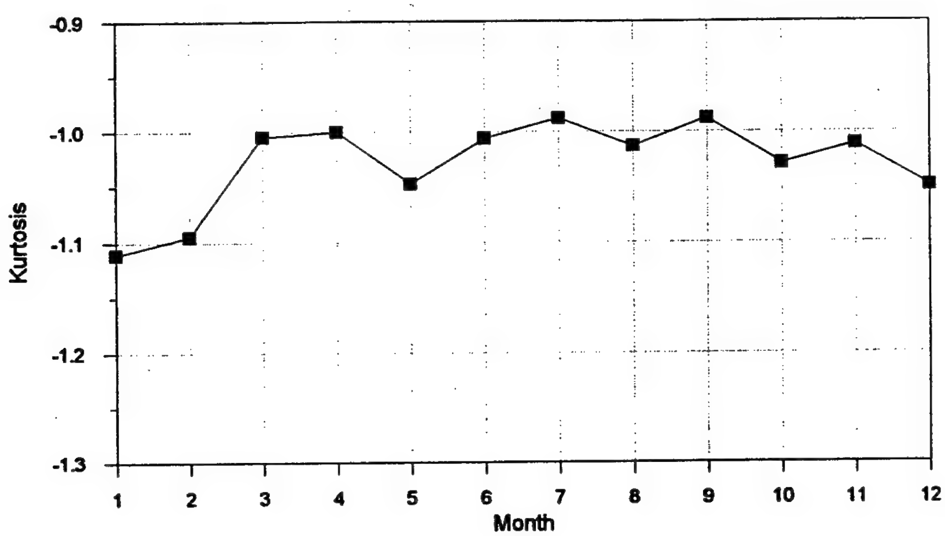

Figure 27. Kurtosis for Monthly Composite Normalized Temperature Frequency Curves

The Spatial Aspects of the Temperature Frequency Groups

Winter: December, January and February

As a whole, the developed model performed worse during the winter than for any other season. More groups were generated for the winter season months than for any other season. Only about 63 percent of the total number of stations (model building and validation data sets) during this season had no errors whatsoever, although about 90 percent of all generated frequency levels were within the +/-2.0C tolerance criterion

December -- December is considered to be the first month of winter, although winter's arrival varies widely across the study area. On or about December 21st, the winter

solstice occurs and the Northern Hemisphere experiences its shortest day. As a whole, December is the stormiest month (Ludlum, 1982), with the Gulf of Alaska and the Great Lakes having high frequencies of passing disturbances. Although the sun reaches its lowest point in the Northern Hemisphere sky, temperatures do not reach their minimum until January at most locations.

Figure 28 shows the December temperature frequency group patterns for North America and Figure 29 shows the same for the islands in the Pacific Ocean. December is comprised of 34 groups. The southeastern portion of the U.S. shows a general southwest to northeast configuration, indicative of the general air mass flow over the area. The pattern also closely fits the continentality pattern shown in Figure 14 for the area. The western boundaries of Groups 32, 3, 6 and 14 also lie close to the "Humid" and "Subhumid" Humidity Provinces shown in Figure 12. To the west, Groups 34, 22 and 23 correspond closely to the Cfa/Dfa and the BSk climate boundaries (McKnight, 1990) and the grassland/steppe boundary (Borchert, 1950). The pattern in the high elevation, western portions of the U.S., takes on a less distinctive configuration with the central U.S. Rockies having an east-west flow, and the northern Rockies up through British Columbia having a north-south trend. Elevation and monthly range are important discriminating variables. Groups 11, 30 and 33 highlight the Subtropical Desert climate type (Bwh). The southern portion of the West Coast of North America clearly shows the Mediterranean Climate Type (Group 10). Continentality was the primary variable splitting the central portions of California (Group 29) from the coastal areas (Group 10). Moving northward along the coast shows the transition to the Marine West Coast climate type (Csb) [Groups 2 and 5]. The patterns in central and northern Canada exhibit a northwest-to-southeast plunge, indicative of the general flow of continental Polar and continental Arctic air masses over the continent during the winter season. The boundary between Group 21 and Group 25 also corresponds quite closely to the Dfc (Subarctic) climate type and the ET (Tundra) climate type (McKnight, 1990) boundary -- corresponding closely to the Arctic tree line (Hare and Hay, 1974).

The groups of the Pacific islands show a general latitudinal or zonal pattern. Looking at the December group means in Table 9, Precipitation Effectiveness (P/E) also appears to be a dominant variable for group differentiation. Group 17 (Lihue, HI) also has a distinctive normalized mean daily maximum and minimum temperature. It is well to the right side of the distribution, indicating a quite pronounced negative skew.

Figures 30 and 31 show the group mean December skewness for North America and the Pacific islands, respectively. As mentioned before, cumulative temperature frequency distributions tend to be skewed in the direction of the prevailing extremes (Court, 1951). It is not surprising then that the dominant group skewness of North America during December is negative. About 85 percent of the groups exhibit a negative skewness. High negative group skewness ($\leq$ -0.3) occurs along the western coastal areas of the U.S. and Canada north of about 45°N. This area is under the dominant

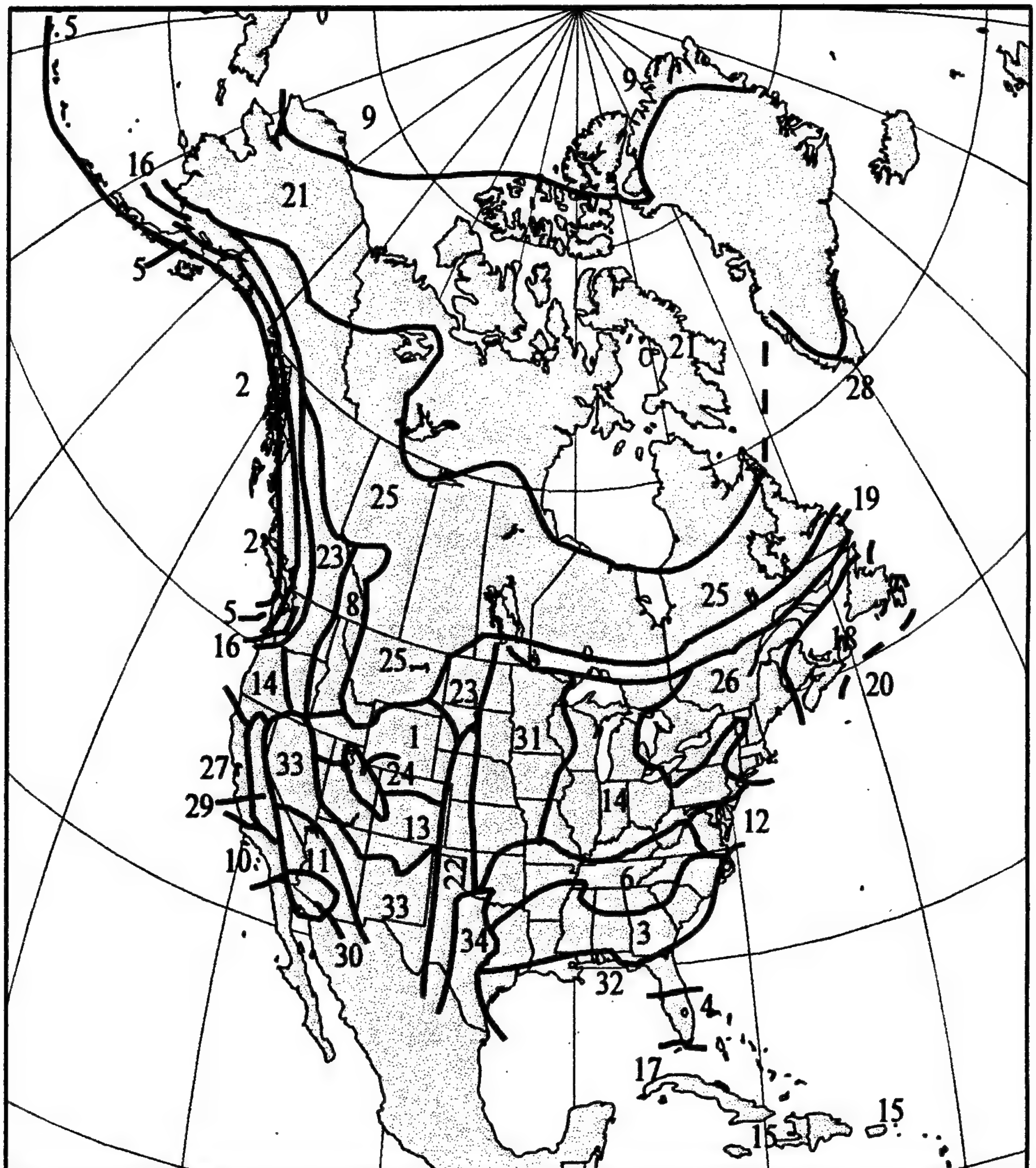

FIGURE 28. NORTH AMERICA TEMPERATURE FREQUENCY GROUPS FOR DECEMBER

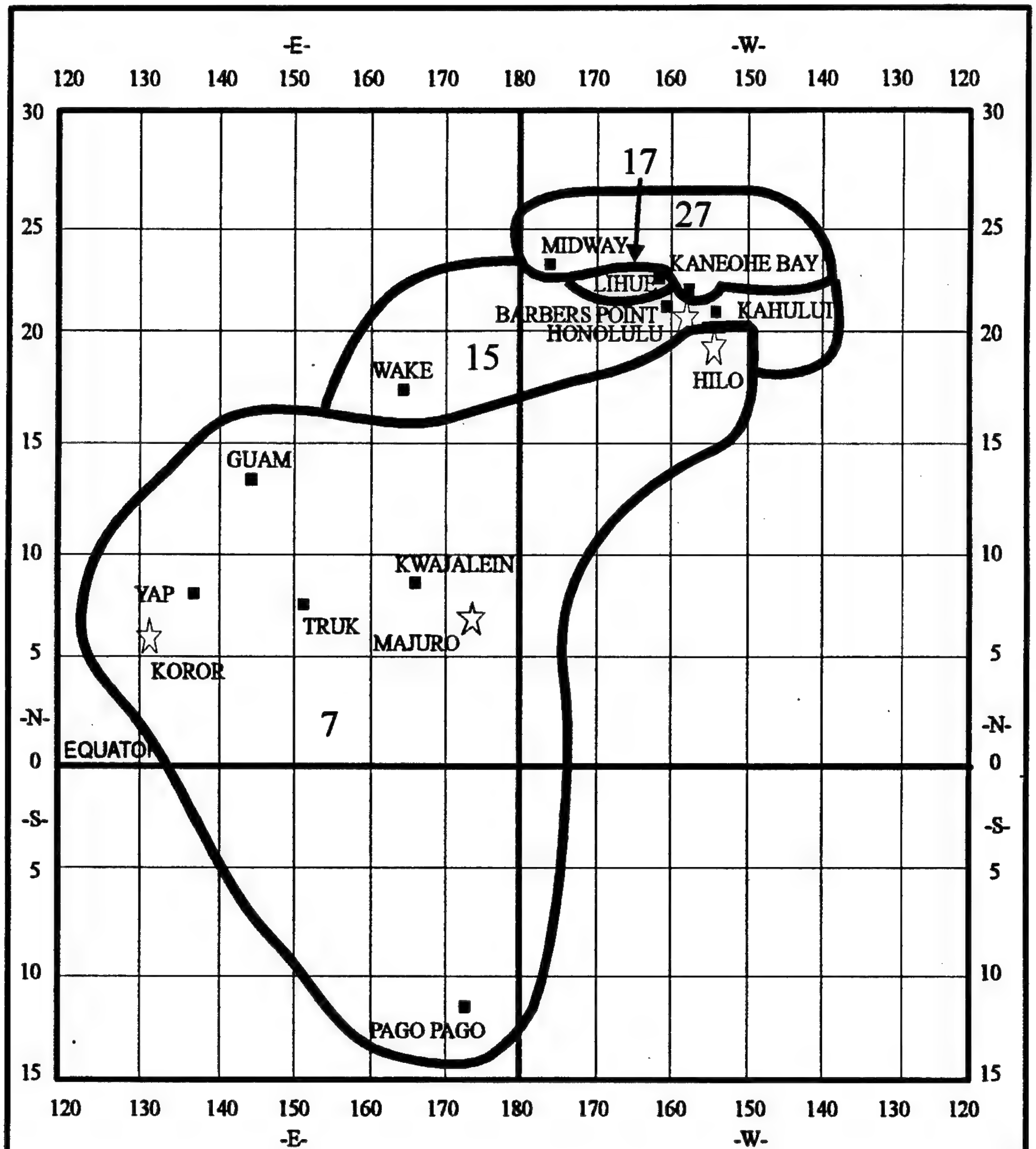

FIGURE 29. PACIFIC ISLANDS TEMPERATURE FREQUENCY GROUPS FOR DECEMBER

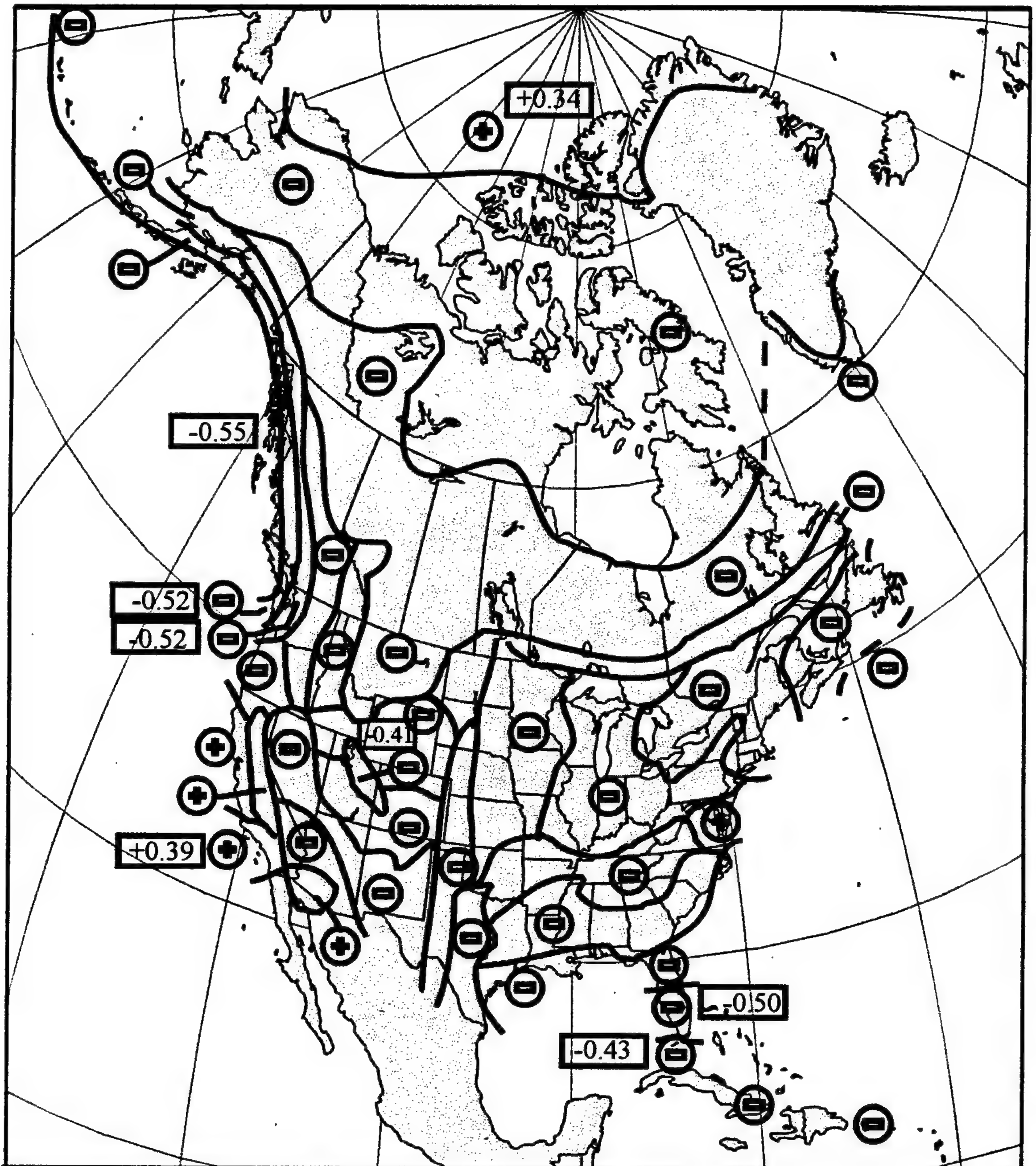

FIGURE 30. NORTH AMERICA TEMPERATURE FREQUENCY GROUP SKEWNESS FOR DECEMBER

⊕ = POSITIVE SKEW ⊖ = POSITIVE SKEW

▭ = VALUES >/= 0.3 OR </= -0.3

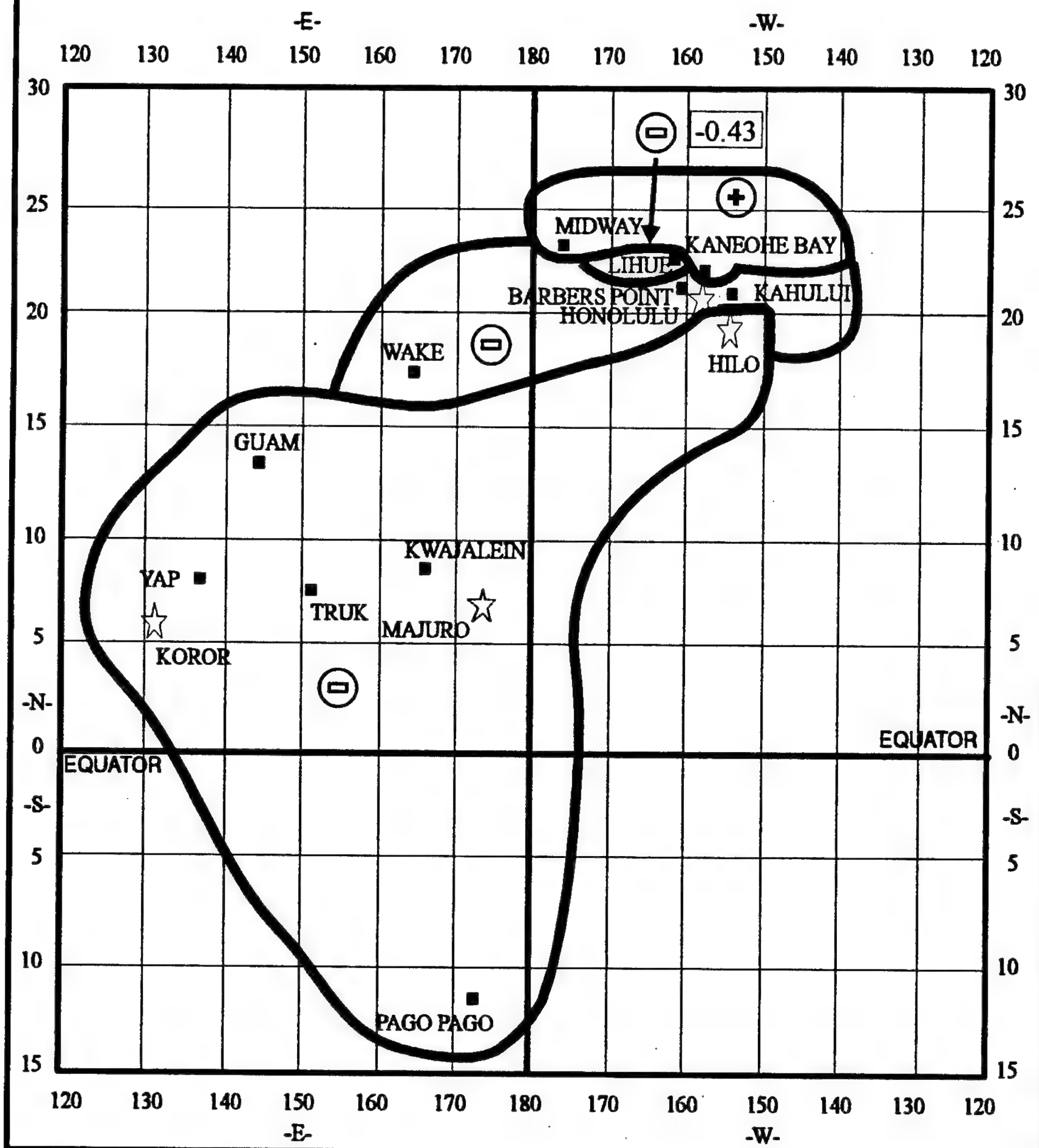

FIGURE 31. PACIFIC ISLANDS TEMPERATURE FREQUENCY GROUP SKEWNESS FOR DECEMBER

(+) = POSITIVE SKEW (−) = NEGATIVE SKEW

☐ = VALUES >/= 0.3 OR </= -0.3

influence of maritime Polar (mP) air masses throughout the winter season. Another area of high negative skewness is found in the central and southern portions of the Florida Peninsula. Court (1951) also noted this, and it appears that the surrounding water temperatures put a cap on the production of high temperatures and the occasional advection of cold continental Polar air masses into the area causes a pronounced negative skew.

Skewness also is highly negative in Group 1, which is centered over Wyoming. This is an area that Lydolph (1985) terms the "polar basin" as, during the winter months, it experiences a high frequency of semi-permanent, cold, stable high pressure systems with strong radiational cooling of the surface air. Sands (1966) describes a number of frequent configurations of high pressure systems in this area -- Polar Basin high, Great Basin high, Colorado Plateau high, and western Middle Rockies high. Klein (1957) also shows that this feature is the one having the greatest frequency of occurrence in CONUS.

Positive skewness is quite pronounced in California. This area is under the dominant influence of maritime Tropical (mT) air masses, while being protected from colder air masses (mP and cP) by mountain ranges to the east. During late fall and early winter, southern California also experience warm chinook (*Santa Ana*) winds, thus, the highest temperatures of the year may be experienced at that time (Lydolph, 1985). Another notable area of high positive skewness is the northern Polar regions. Court (1951) noted that temperature at the 500 mb level in the Arctic during winter exhibits a positive skew. Crowe (1971) stated that although radiation in the winter at these extremely high latitudes is practically nil, there is a steady heat supply--the slow conduction of heat through several meters of sea ice from the unfrozen water beneath. This then can provide the necessary warmer temperatures so that the temperature frequency distribution would exhibit a positive skew. Group 12, located in the areas surrounding Chesapeake Bay, exhibits a slight positive skew (+0.018). This could be the result of the modifying influences of the Bay itself and the adjacent Atlantic Ocean.

The skewness in the Pacific islands is generally negative, with the exception of the northernmost group (27), whose skewness is only slightly positive (+0.03). During the winter months, the weakened Pacific high permits a closer approach of passing cyclones from more northern latitudes (Armstrong, 1973). The large negative skewness for group 17 is due to the fact that Lihue, HI is grouped with two stations in the Florida Keys that possess high negative skewness (< -0.6).

December group means for the attribute variables appear in Table 9, group mean normalized temperatures in Table 10, discriminant functions in Table 11, curve-fitting equations in Table 12, and percent probabilities by frequency level in Table 13.

<u>January</u> -- Most of the study area will experience its coldest spells of weather during January. One-half of the states of the U.S. have experienced their all time extreme

Table 9. Group Means for December

Group	Station Count	Latitude	Elevation	P/E	Continentality	Temperature Range Monthly	Temperature Range Daily	Normalized Mean Daily Max Temp	Normalized Mean Daily Min Temp
1	5	41.51	4961	27.4	41.2	102.8	24.2	72.0	48.4
2	2	53.74	104	338.0	11.8	66.5	12.0	71.7	53.3
3	12	33.13	242	85.5	34.6	77.1	22.5	70.4	41.1
4	4	26.76	16	69.5	15.1	62.3	18.5	80.0	50.3
5	2	47.67	8	168.8	10.6	54.0	10.5	73.1	53.7
6	12	36.45	1034	90.6	39.6	83.4	19.8	66.0	42.2
7	5	10.70	62	147.9	-9.9	23.8	9.8	75.8	34.5
8	3	49.74	2564	47.5	35.9	89.3	14.3	71.6	55.7
9	4	73.30	36	26.8	40.8	82.5	11.5	50.7	36.5
10	5	33.46	44	16.9	6.6	58.4	18.4	58.0	26.6
11	3	34.63	2343	8.1	40.6	67.7	26.0	71.8	33.5
12	7	38.40	75	86.5	38.6	75.0	17.3	59.2	36.2
13	3	37.88	5567	25.2	41.7	90.3	25.0	67.5	39.7
14	22	41.35	673	88.7	44.2	89.7	14.9	62.5	45.9
15	4	20.35	37	28.7	-0.9	35.0	13.8	74.6	35.8
16	3	50.65	97	70.1	17.3	74.0	12.7	72.6	55.5
17	2	23.27	54	51.3	4.8	39.0	10.0	74.6	48.2
18	5	45.51	264	182.3	32.1	66.8	13.6	63.7	43.1
19	2	51.61	464	76.6	52.7	80.0	14.5	57.5	39.4
20	2	46.44	254	147.1	29.6	58.5	11.0	61.9	43.0
21	5	64.43	474	46.5	43.5	96.4	14.4	61.1	46.1
22	5	38.74	2814	31.7	46.1	105.2	25.0	64.6	40.8
23	4	46.99	1810	27.9	49.3	101.3	19.5	65.6	46.4
24	2	39.94	4536	27.8	49.6	81.5	18.0	66.9	44.8
25	6	46.80	3721	33.0	39.4	97.3	17.8	68.8	50.5
26	15	42.31	428	105.2	42.8	81.9	14.0	58.8	41.7
27	6	32.58	49	35.2	3.9	41.7	11.5	63.3	35.4
28	4	59.79	126	97.5	11.6	56.3	8.0	60.2	45.7
29	3	36.76	250	19.0	30.6	61.3	17.7	62.1	33.3
30	2	33.04	659	6.0	40.0	62.5	25.5	69.6	28.8
31	13	41.76	1183	59.3	53.7	95.5	18.8	62.9	43.2
32	14	30.71	59	84.6	29.3	74.6	20.2	73.4	46.2
33	6	34.94	3673	16.5	40.0	84.7	27.0	70.0	38.0
34	6	29.47	230	41.7	35.3	82.5	20.7	69.8	44.6
ALL	198	39.32	985	72.6	34.1	77.9	17.5	66.0	42.6

Table 10. Group Mean Normalized Temperatures: December

Group	Frequency Levels																				
	0	0.001	0.005	0.01	0.03	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	0.95	0.97	0.99	0.995	0.999	1.0
1	0	8.37	17.58	22.67	31.99	36.26	42.20	48.71	53.16	56.68	59.85	62.91	66.12	69.77	74.95	79.29	81.94	86.53	88.58	92.46	100
2	0	11.40	19.54	23.72	31.85	36.17	42.98	50.83	56.59	61.16	64.87	68.11	70.77	73.87	77.78	80.43	82.03	84.88	86.03	90.28	100
3	0	6.55	14.86	18.80	24.91	27.85	32.67	39.49	44.81	49.36	53.77	58.34	63.24	68.84	75.88	80.77	83.79	88.68	90.71	94.20	100
4	0	9.00	18.06	22.47	29.51	33.79	41.00	50.56	57.23	61.99	65.94	69.43	72.70	76.42	81.69	85.24	86.98	90.18	91.77	94.69	100
5	0	7.10	14.05	19.12	31.66	37.68	43.10	50.53	55.51	59.56	63.13	66.63	70.12	73.38	76.96	80.59	82.76	86.86	89.46	94.37	100
6	0	6.45	14.85	19.20	25.90	29.45	34.78	40.89	45.25	48.93	52.54	56.23	60.43	65.48	72.55	77.66	80.66	85.90	88.55	92.88	100
7	0	13.83	21.23	24.47	29.61	32.49	36.72	41.62	45.43	48.42	51.46	54.60	58.70	63.42	68.90	72.46	74.55	79.78	81.68	84.94	100
8	0	5.55	16.10	21.46	30.31	35.53	43.33	51.35	57.73	61.64	65.35	68.60	71.68	74.86	79.14	82.68	84.79	88.57	90.53	94.42	100
9	0	5.05	8.80	10.57	14.99	17.37	21.43	26.75	31.30	35.89	39.98	43.86	49.53	55.72	64.04	72.88	79.36	87.82	91.25	95.40	100
10	0	5.57	9.96	12.58	17.25	19.94	23.93	29.08	33.07	36.64	39.76	42.72	45.92	49.90	56.12	62.35	66.86	75.17	79.08	86.19	100
11	0	8.74	14.91	18.04	23.63	26.52	31.13	36.87	41.53	45.77	50.06	54.41	59.09	64.94	72.14	77.12	80.12	85.23	87.75	92.72	100
12	0	4.14	11.11	14.14	20.12	23.08	27.99	34.12	38.65	42.42	46.02	49.64	53.64	58.62	66.24	72.36	76.19	82.51	85.45	91.00	100
13	0	7.94	13.42	18.12	25.58	29.55	35.20	41.05	45.24	48.58	51.69	55.18	59.05	63.81	70.62	75.67	78.64	83.99	86.53	90.63	100
14	0	7.73	15.40	19.34	26.55	30.53	36.41	43.16	47.66	51.12	54.17	57.04	60.01	63.73	69.43	74.80	78.31	84.52	87.19	92.14	100
15	0	10.24	16.38	19.20	25.29	28.55	33.43	39.03	42.94	46.42	50.08	54.18	58.82	63.74	69.90	74.21	76.64	80.38	83.04	87.21	100
16	0	10.12	19.39	24.07	32.49	36.61	42.78	49.82	55.61	61.42	66.07	70.34	74.06	77.48	81.43	84.30	86.03	89.29	91.24	94.37	100
17	0	10.09	17.41	22.55	30.25	34.64	40.73	48.52	53.72	57.56	61.23	64.50	67.73	71.05	75.67	79.16	80.98	84.67	86.52	91.19	100
18	0	6.21	13.19	16.30	21.74	25.33	31.79	39.66	45.62	50.15	53.67	57.13	60.83	65.55	72.99	79.07	81.65	86.68	89.49	93.89	100
19	0	1.65	6.04	7.98	13.65	16.98	21.87	28.16	34.00	40.64	47.65	52.47	58.81	65.89	72.96	77.38	79.87	83.54	86.62	94.11	100
20	0	1.78	10.56	15.02	21.99	25.47	30.37	37.49	42.64	47.24	51.41	54.72	58.44	62.78	69.35	75.18	78.59	83.55	85.90	90.76	100
21	0	3.29	7.91	11.11	16.88	20.58	25.86	35.73	42.84	48.19	53.19	58.18	63.54	69.96	77.46	82.77	86.05	90.72	92.66	95.95	100
22	0	9.72	14.98	17.86	25.23	29.22	34.52	40.63	44.80	48.08	51.10	54.07	57.39	61.47	67.24	72.36	75.55	81.09	83.88	88.77	100
23	0	8.77	15.26	18.59	26.08	30.07	36.58	43.65	48.70	52.83	56.48	59.85	63.05	66.69	71.54	75.44	77.87	82.87	85.71	91.13	100
24	0	7.49	17.00	22.05	29.70	33.32	38.93	44.43	48.15	51.20	54.01	56.95	59.96	63.51	69.13	73.67	76.41	82.32	84.82	89.60	100
25	0	5.92	12.79	16.36	25.13	30.14	37.43	46.89	52.82	57.36	61.16	64.47	67.67	71.22	75.85	79.65	81.73	85.97	88.34	93.13	100
26	0	6.48	13.33	16.78	22.77	26.25	31.53	38.47	43.15	47.11	50.40	53.51	56.51	60.26	65.94	71.51	75.36	81.80	84.66	90.61	100
27	0	6.55	13.24	16.61	22.09	25.09	29.73	35.38	39.50	42.98	46.24	49.53	52.97	56.86	62.13	66.69	69.49	75.64	78.66	86.10	100
28	0	3.95	8.73	12.43	19.94	23.54	28.89	35.47	41.33	46.82	51.67	56.18	60.70	64.88	71.65	77.58	81.26	87.07	89.94	94.37	100
29	0	6.16	13.57	16.06	21.17	23.87	28.25	33.74	37.56	41.21	44.77	48.41	52.42	57.16	63.73	68.88	72.25	78.02	81.26	87.42	100
30	0	6.47	10.90	13.48	18.95	21.87	26.53	32.47	37.13	41.42	45.76	50.08	54.78	60.69	68.66	74.24	77.28	82.22	84.73	89.87	100
31	0	5.96	11.86	15.18	22.42	26.55	33.02	40.72	46.10	50.26	53.68	56.76	60.01	63.64	68.90	73.82	77.18	83.09	86.27	91.57	100
32	0	7.49	16.92	21.37	28.00	31.28	36.75	44.11	49.73	54.57	59.07	63.56	68.13	73.02	78.91	83.06	85.42	89.05	90.81	93.79	100
33	0	5.94	14.78	18.98	26.06	29.36	34.00	39.59	43.75	47.51	51.44	55.55	59.92	65.18	72.05	77.04	80.01	85.23	87.60	92.53	100
34	0	8.41	16.34	20.72	28.23	31.57	36.36	42.23	46.63	50.82	54.92	59.26	63.89	68.82	74.35	78.58	81.10	85.07	87.17	91.33	100

Table 11. Discriminant Function Values: December

Function value = (a x lat) + (b x elev) + (c x P/E) + (d x K) + (e x mrange) + (f x drange) + (g x nmax) + (h x nmin) + constant

Group	a	b	c	d	e	f	g	h	constant
1	8.116	0.060	-0.573	1.192	9.935	-41.231	46.387	-28.772	-1323.00
2	9.560	0.019	0.768	-0.519	9.328	-41.468	44.574	-29.683	-1257.14
3	7.389	0.016	-0.296	1.168	9.222	-39.533	44.343	-29.309	-1003.11
4	7.193	0.016	-0.437	0.254	10.323	-44.817	48.282	-31.305	-1136.73
5	9.397	0.016	-0.021	-0.105	9.313	-42.690	45.353	-29.047	-1129.17
6	7.379	0.023	-0.281	1.313	9.457	-40.852	44.166	-29.243	-995.58
7	5.816	0.018	-0.004	-1.005	14.521	-66.467	62.499	-48.038	-1426.84
8	9.242	0.038	-0.616	0.995	10.701	-47.411	49.058	-30.850	-1321.00
9	12.003	0.009	-0.668	1.063	10.017	-46.454	46.896	-32.574	-1196.33
10	7.667	0.011	-0.509	-0.627	10.473	-44.664	46.204	-33.772	-911.77
11	8.310	0.035	-0.595	1.920	9.338	-41.935	48.402	-32.612	-1188.45
12	7.537	0.013	-0.272	1.310	9.220	-40.771	43.029	-29.588	-894.38
13	7.743	0.065	-0.486	1.488	9.148	-38.750	44.678	-28.483	-1227.20
14	7.619	0.019	-0.355	1.393	10.217	-44.842	45.466	-30.304	-1031.71
15	7.118	0.015	-0.568	-0.465	13.009	-59.060	58.015	-42.535	-1293.22
16	9.701	0.015	-0.526	-0.032	10.298	-45.429	47.342	-29.938	-1212.25
17	6.814	0.015	-0.503	-0.036	10.799	-49.449	49.519	-33.226	-1079.45
18	8.510	0.017	0.116	0.994	9.075	-41.510	43.892	-29.691	-1004.17
19	9.101	0.016	-0.389	2.155	9.172	-42.668	43.377	-29.099	-966.92
20	8.726	0.016	-0.045	1.020	8.850	-41.539	49.287	-33.075	-1287.01
21	10.890	0.016	-0.636	1.094	10.877	-48.521	43.744	-28.351	-1074.43
22	7.433	0.038	-0.521	1.337	9.641	-39.297	47.073	-30.579	-1186.78
23	8.601	0.029	-0.647	1.606	10.352	-44.642	46.263	-29.430	-1220.87
24	7.939	0.056	-0.559	2.217	9.403	-42.818	48.447	-30.921	-1301.43
25	8.693	0.048	-0.616	1.053	10.711	-46.215	43.919	-29.797	-952.11
26	7.708	0.017	-0.242	1.409	9.681	-43.181	48.510	-34.496	-989.04
27	7.813	0.013	-0.500	-0.366	10.698	-48.539	48.510	-34.496	-989.04
28	10.636	0.013	-0.315	-0.253	9.143	-42.322	43.639	-28.743	-1049.72
29	8.042	0.014	-0.572	1.134	9.638	-43.562	46.098	-32.010	-973.34
30	8.241	0.019	-0.610	1.899	9.790	-44.340	49.776	-34.965	-1152.12
31	7.749	0.023	-0.469	2.004	9.830	-42.997	45.182	-29.842	-1060.58
32	7.140	0.015	-0.338	0.887	9.631	-41.375	45.268	-29.467	-1033.61
33	7.709	0.047	-0.537	1.518	8.868	-37.433	44.315	-28.416	-1131.88
34	6.729	0.015	-0.524	1.137	9.685	-41.042	44.350	-28.797	-993.44

INPUT VARIABLES
lat = latitude
elev = elevation
P/E = Precipitation Effectiveness Index
K = Continentality
mrange = monthly temperature range
drange = daily temperature range
nmax = normalized mean daily maximum temperature
nmin = normalized mean daily minimum temperature

Table 12. Temperature Frequency Equations: December

Group	If Input Normalized Temperature (T) < 50th Percentile Normalized Temperature (T)	Maximum Error E1	Maximum Error E2	50th Percentile Normalized T	Group	If Input Normalized Temperature (T) > 50th Percentile Normalized Temperature (T)	Maximum Error E3	Maximum Error E4
1	F=-0.0045+0.00361655*T-0.000274568*T^2+5.92411e-006*T^3	0.008	0.004	59.85	1	F=-7.6447+0.263654*T-0.00267216*T^2+8.99888e-006*T^3	0.007	0.002
2	F=-0.0009+0.00133625*T-0.000119454*T^2+3.35478e-006*T^3	0.002	0.001	64.87	2	F=53.5408-2.86174*T+0.0561619*T^2-0.000476107*T^3+1.48121e-006*T^4	0.006	0.003
3	F=0.0055-0.00227047*T+7.87859e-005*T^2+2.55791e-006*T^3	0.007	0.008	53.77	3	F=-1.7181+0.0576457*T-0.00030742*T^2+2.34174e-008*T^3	0.005	0.004
4	F=-0.0012+0.000758972*T-6.535e-005*T^2+2.54965e-006*T^3	0.001	0.006	65.94	4	F=-4.9084+0.132316*T-0.000825453*T^2+9.26983e-007*T^3	0.009	0.007
5	F=-0.0034+0.00263986*T-0.000198184*T^2+4.48182e-006*T^3	0.006	0.002	63.13	5	F=38.7083-2.08739*T+0.0413102*T^2-0.000351665*T^3+1.09597e-006*T^4	0.010	0.009
6	F=0.0005+0.000989215*T-0.000148138*T^2+5.95896e-006*T^3	0.003	0.007	52.54	6	F=-1.1942+0.00896648*T+0.00113863*T^2-1.67245e-005*T^3+6.63567e-008*T^4	0.001	0.000
7	F=-3.6981849E-005+0.00346678*T-0.000362279*T^2+9.45433e-006*T^3	0.004	0.008	51.46	7	F=-3.9273+0.150832*T-0.00152026*T^2+5.04462e-006*T^3	0.010	0.010
8	F=-0.0037+0.00227173*T-0.000151379*T^2+3.57425e-006*T^3	0.006	0.004	65.35	8	F=34.7185-1.87941*T+0.0371431*T^2-0.000314478*T^3+9.7271e-007*T^4	0.004	0.005
9	F=0.0074-0.00547192*T+0.000513156*T^2-1.61324e-006*T^3	0.008	0.010	39.98	9	F=-1.4142+0.0747108*T-0.00077974*T^2+2.74168e-006*T^3	0.006	0.004
10	F=0.0041-0.00221634*T+0.000115514*T^2+6.48512e-006*T^3	0.005	0.008	39.76	10	F=-4.5321+0.252403*T-0.00433763*T^2+3.3214e-005*T^3-9.54563e-008*T^4	0.005	0.006
11	F=-0.0013+0.00460993*T-0.000632775*T^2+2.61348e-005*T^3-2.26172e-007*T^4	0.005	0.005	50.06	11	F=-1.9889+0.0766402*T-0.000610747*T^2+1.42848e-006*T^3	0.005	0.003
12	F=0.0030-0.00111665*T+2.64896e-005*T^2+5.11816e-006*T^3	0.004	0.006	46.02	12	F=-2.7577+0.120003*T-0.00127975*T^2+4.55539e-006*T^3	0.003	0.001
13	F=-0.0022+0.00262622*T-0.000254782*T^2+7.60003e-006*T^3	0.005	0.004	51.69	13	F=-3.7249+0.143601*T-0.00144874*T^2+4.85098e-006*T^3	0.002	0.002
14	F=-0.0031+0.00268198*T-0.00023451*T^2+6.56811e-006*T^3	0.005	0.003	54.17	14	F=-6.6086+0.251526*T-0.00277373*T^2+1.01954e-005*T^3	0.006	0.005
15	F=0.0016+0.000681657*T-0.000154256*T^2+6.86853e-006*T^3	0.003	0.011	50.08	15	F=3.5627-0.248171*T+0.00634086*T^2-6.2953e-005*T^3+2.17986e-007*T^4	0.001	0.001
16	F=-0.0019+0.00342291*T-0.000335844*T^2+9.85865e-006*T^3-5.77868e-008*T^4	0.006	0.007	66.07	16	F=74.1794-3.70392*T+0.0683752*T^2-0.000549552*T^3+1.63013e-006*T^4	0.004	0.003
17	F=-0.0018+0.00191148*T-0.000162124*T^2+4.32504e-006*T^3	0.004	0.004	61.23	17	F=18.7004-1.09925*T+0.0233415*T^2-0.000208538*T^3+6.7349e-007*T^4	0.003	0.004
18	F=-2.3435497E-006-9.24164e-005*T-4.29613e-006*T^2+3.32498e-006*T^3	0.001	0.003	53.67	18	F=-4.1394+0.155262*T-0.00156539*T^2+5.26789e-006*T^3	0.003	0.004
19	F=0.0088-0.00554489*T+0.000587647*T^2-5.31549e-006*T^3	0.010	0.011	47.65	19	F=1.2577-0.0827825*T+0.00227663*T^2-2.14754e-005*T^3+6.72605e-008*T^4	0.010	0.007
20	F=0.0036-0.00171472*T+7.98014e-005*T^2+2.79793e-006*T^3	0.007	0.007	51.41	20	F=-4.2109+0.164719*T-0.00173636*T^2+6.1028e-006*T^3	0.003	0.002
21	F=0.0011-0.00102312*T+0.000160701*T^2+6.55215e-007*T^3	0.002	0.003	53.19	21	F=-1.0268+0.0330846*T-3.0887e-005*T^2-9.75723e-007*T^3	0.002	0.003
22	F=-0.0017+0.00257925*T-0.000255828*T^2+7.78739e-006*T^3	0.005	0.003	51.10	22	F=-5.0745+0.201134*T-0.00221828*T^2+8.14424e-006*T^3	0.003	0.002
23	F=-0.0005+0.00105217*T-0.000114916*T^2+4.49731e-006*T^3	0.001	0.002	56.48	23	F=4.5196-0.357227*T+0.00930852*T^2-9.36916e-005*T^3+3.28108e-007*T^4	0.006	0.006
24	F=-0.0057+0.00482306*T-0.000391421*T^2+8.79593e-006*T^3	0.005	0.007	54.01	24	F=-6.6416+0.252553*T-0.00277947*T^2+1.01813e-005*T^3	0.007	0.002
25	F=-0.0027+0.00146197*T-9.22129e-005*T^2+3.30094e-006*T^3	0.002	0.004	61.16	25	F=14.4060-0.872976*T+0.0189359*T^2-0.000170979*T^3+5.55127e-007*T^4	0.004	0.005
26	F=0.0004+0.000389091*T-8.15218e-005*T^2+5.37561e-006*T^3	0.001	0.002	50.40	26	F=-5.2985+0.213289*T-0.00240612*T^2+9.03291e-006*T^3	0.006	0.006
27	F=0.0018+3.65361e-005*T-0.000100364*T^2+7.26104e-006*T^3	0.004	0.006	46.24	27	F=-4.0712+0.175234*T-0.0020091*T^2+7.63835e-006*T^3	0.008	0.004
28	F=0.0078-0.00335649*T+0.000223774*T^2+5.42302e-007*T^3	0.008	0.010	51.67	28	F=2.5565-0.19337*T+0.00518224*T^2-5.21627e-005*T^3+1.81232e-007*T^4	0.009	0.004
29	F=0.0041-0.00160871*T+1.24338e-005*T^2+6.16976e-006*T^3	0.005	0.011	44.77	29	F=-2.7872+0.123689*T-0.00134222*T^2+4.83927e-006*T^3	0.005	0.004
30	F=0.0064-0.00343685*T+0.000222058*T^2+2.04768e-006*T^3	0.007	0.010	45.76	30	F=-1.7859+0.0778276*T-0.000703656*T^2+2.03761e-006*T^3	0.002	0.005
31	F=-0.0013+0.00103166*T-8.6758e-005*T^2+4.48821e-006*T^3	0.001	0.001	53.68	31	F=-6.1885+0.235574*T-0.00257153*T^2+9.34637e-006*T^3	0.007	0.003
32	F=0.0042-0.00135895*T+1.85548e-005*T^2+2.51885e-006*T^3	0.006	0.007	59.07	32	F=-1.2783+0.0259157*T+0.00021583*T^2-2.47697e-006*T^3	0.006	0.008
33	F=-0.0039+0.00523505*T-0.000605359*T^2+2.11439e-005*T^3-1.47933e-007*T^4	0.009	0.007	51.44	33	F=-2.6296+0.0992545*T-0.000874473*T^2+2.44531e-006*T^3	0.005	0.005
34	F=-0.0027+0.00499518*T-0.000556964*T^2+1.83206e-005*T^3-1.23315e-007*T^4	0.009	0.006	54.92	34	F=8.4812-0.506043*T+0.0110997*T^2-0.000100327*T^3+3.24527e-007*T^4	0.004	0.001

E1 = Maximum Prediction Error When Computed Frequency < 5%
E2 = Maximum Prediction Error When Computed Frequency Between 5 - 50%
E3 = Maximum Prediction Error When Computed Frequency Between 50 - 95%
E4 = Maximum Prediction Error When Computed Frequency >95%

Table 13. Percent Probability of Predicted Temperatures >2.0C at Each Frequency Level by Group

Month: December

GROUP	STANDARDIZED FREQUENCY LEVELS 0.001	0.005	0.01	0.03	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	0.95	0.97	0.99	0.995	0.999	% OF ALL > 2.0C
1	25	25	25	0	0	0	0	0	0	0	25	25	25	25	25	0	0	0	0	14.5
2	0	0	0	0	0	0	0	50	50	50	0	0	0	0	0	0	0	0	0	7.9
3	0	0	0	0	0	0	0	0	8	8	8	8	8	0	0	0	0	0	0	2.2
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
5	0	50	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5.3
6	0	0	0	0	0	0	0	0	0	0	0	0	0	8	16	8	8	8	8	3.1
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
8	0	0	0	33	33	33	33	0	0	0	0	0	0	0	0	0	0	0	0	7.0
9	0	0	0	0	0	0	0	0	25	25	25	25	25	25	0	0	0	0	0	7.9
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
13	33	33	33	33	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8.8
14	4	9	9	9	4	0	0	4	4	4	4	4	4	13	9	9	13	13	9	6.2
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
16	33	33	33	33	33	33	33	33	0	0	0	0	0	0	0	0	0	0	0	14.0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
21	0	0	0	0	0	0	0	0	0	0	0	0	20	20	20	40	20	20	20	8.4
22	20	20	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.2
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
25	0	17	17	17	17	17	17	17	17	0	0	0	0	0	0	0	0	0	0	5.3
26	0	0	0	7	7	7	0	0	0	0	0	0	0	0	0	0	0	0	0	1.4
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
31	8	8	8	16	16	8	8	8	8	8	8	8	8	8	16	16	24	16	16	11.7
32	14	7	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.5
33	0	17	17	17	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.5
34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0

minimum temperatures during January (Changery, 1995). Several reasons that the coldest weather does not occur on the shortest day (roughly December 21st) are that: 1) the earth's surface continues to lose more heat than it gains from the sun long after the winter solstice; 2) the cold from far northerly regions gets progressively more severe while the sun remains below the horizon; and, 3) the great continental snow fields expand leading to a lowering of surface air temperatures.

Figure 32 shows the January temperature frequency group patterns for North America and Figure 33 shows the same for the islands in the Pacific Ocean. January is comprised of 35 groups. Like December, the January patterns show a southwest-to-northeast alignment in the eastern U.S. and eastern Canada, indicative of the prevailing air mass and storm track flow. The northern boundary of Groups 32 and 21 is quite close to the northern boundary of the Cfa (humid subtropical) climate type. Once again, the patterns of the southeast U.S. coincide quite closely to the continentality patterns for the area (Figure 14). Likewise, the western boundaries of Groups 32, 33 and 5 agree closely with the "Humid" and "Subhumid" P/E boundary shown in Figure 10. A north-to-south boundary, comprised of Groups 25 and 30, represents the Cfa/Dfa and Bsk (steppe) boundary. Groups 11 and 23 represent the desert Southwest, and Group 1 covers the southern and central portions of the Rockies. The Mediterranean climate (Cs) of southern California is represented by Group 12, and moving northward, we find the Marine West Coast climate type represented by Groups 2 and 13.

Group 26 is split between a region of southeast Michigan and an area that encompasses western New York State, central Pennsylvania, New Jersey, Maryland and Delaware. These areas, downwind of the Great Lakes, may very well be showing the modifying influences that the Lakes have on passing cold air masses. The patterns in Canada show, as they did in December, a northwest to southeast dip, with the southern boundary of Group 29 close to the ET/Dfc (tree line) boundary and the southern boundary of Group 14 resembling the southern boundary of the 50-59 continentality index boundary (Figure 14).

The Pacific islands are divided into four groups based primarily on latitude. The group means for January (Table 14) show that precipitation effectiveness (P/E) varies dramatically between the groups and is a strong discriminating variable.

It also is interesting to compare Court's January map (Figure 3) with the temperature frequency map (Figure 28). Groups 32 and 33 correspond very closely with Court's Region III. And, Court's Region I, which encompasses the U.S. Pacific coastal areas, can be compared directly to Groups 12, 24 and 24.

Figures 34 and 35 show the group mean January skewness for North America and the Pacific islands, respectively. For North America, the northern portions of Canada and the Canadian Archipelago are maintaining their positive skewness, as is the Mediterranean

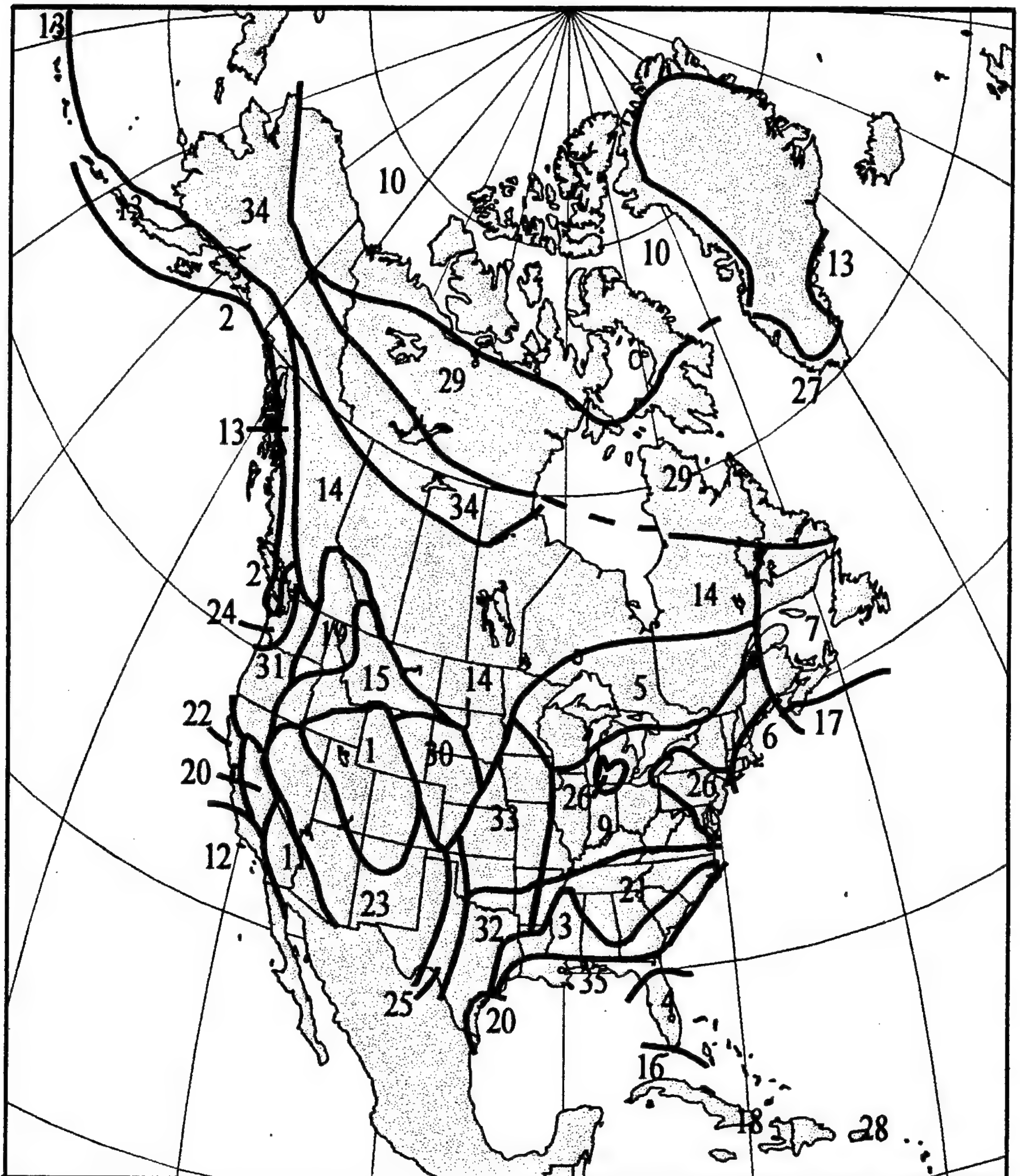

FIGURE 32. NORTH AMERICA TEMPERATURE FREQUENCY GROUPS FOR JANUARY

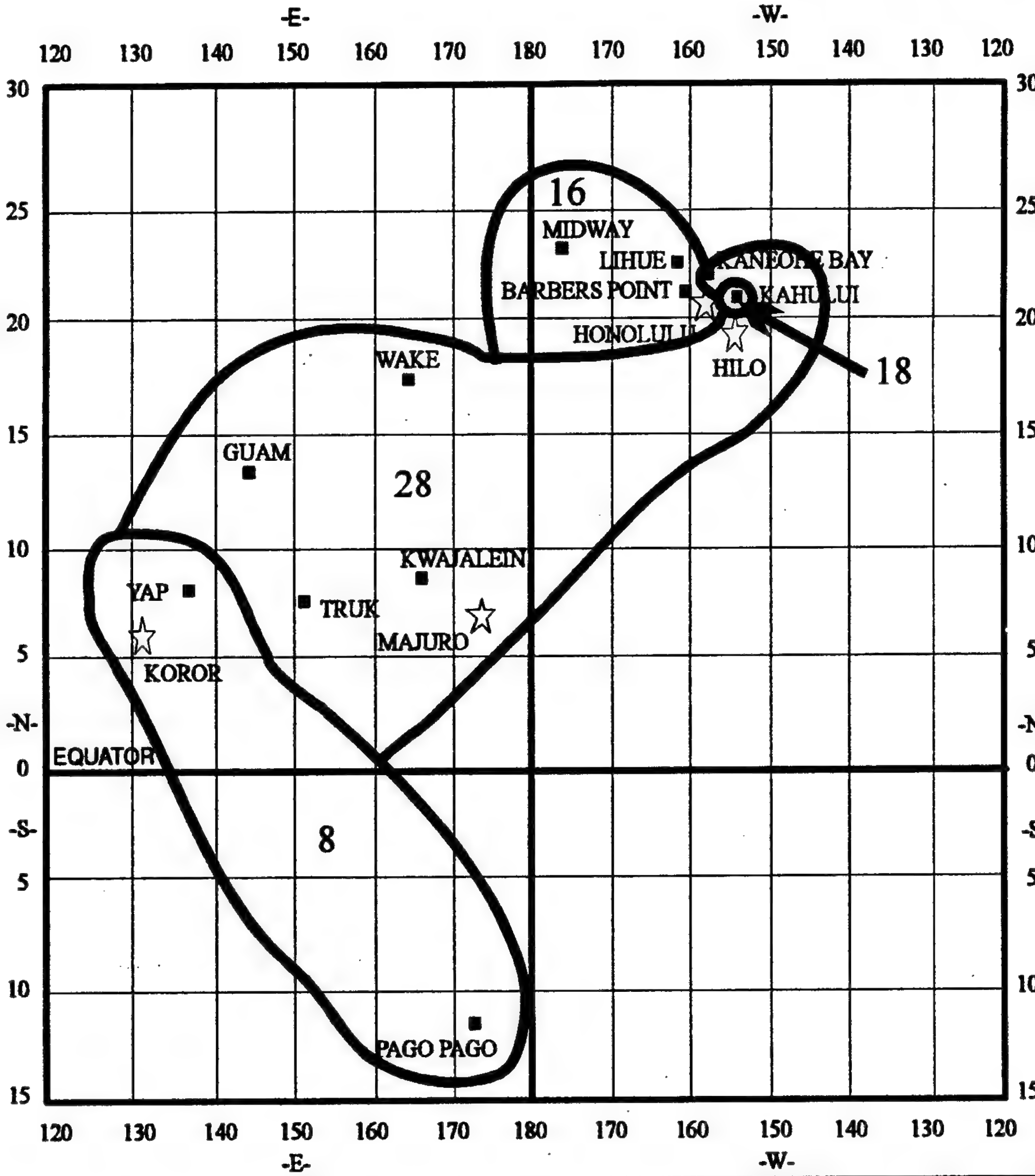

FIGURE 33. PACIFIC ISLANDS TEMPERATURE FREQUENCY GROUPS FOR JANUARY

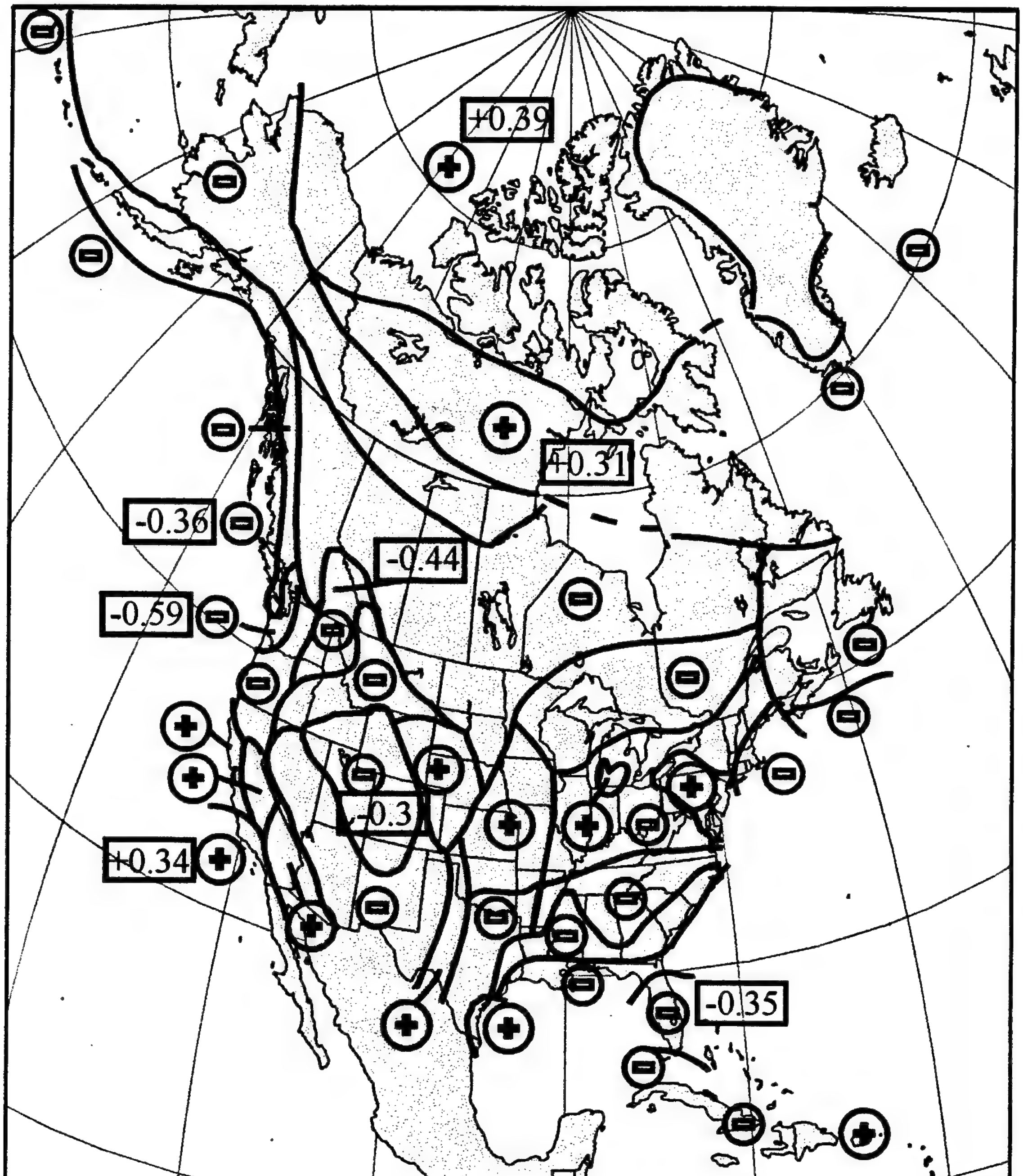

FIGURE 34. NORTH AMERICA TEMPERATURE FREQUENCY GROUP SKEWNESS FOR JANUARY

= POSITIVE SKEW   = NEGATIVE SKEW

= VALUES >/= 0.3 OR </= -0.3

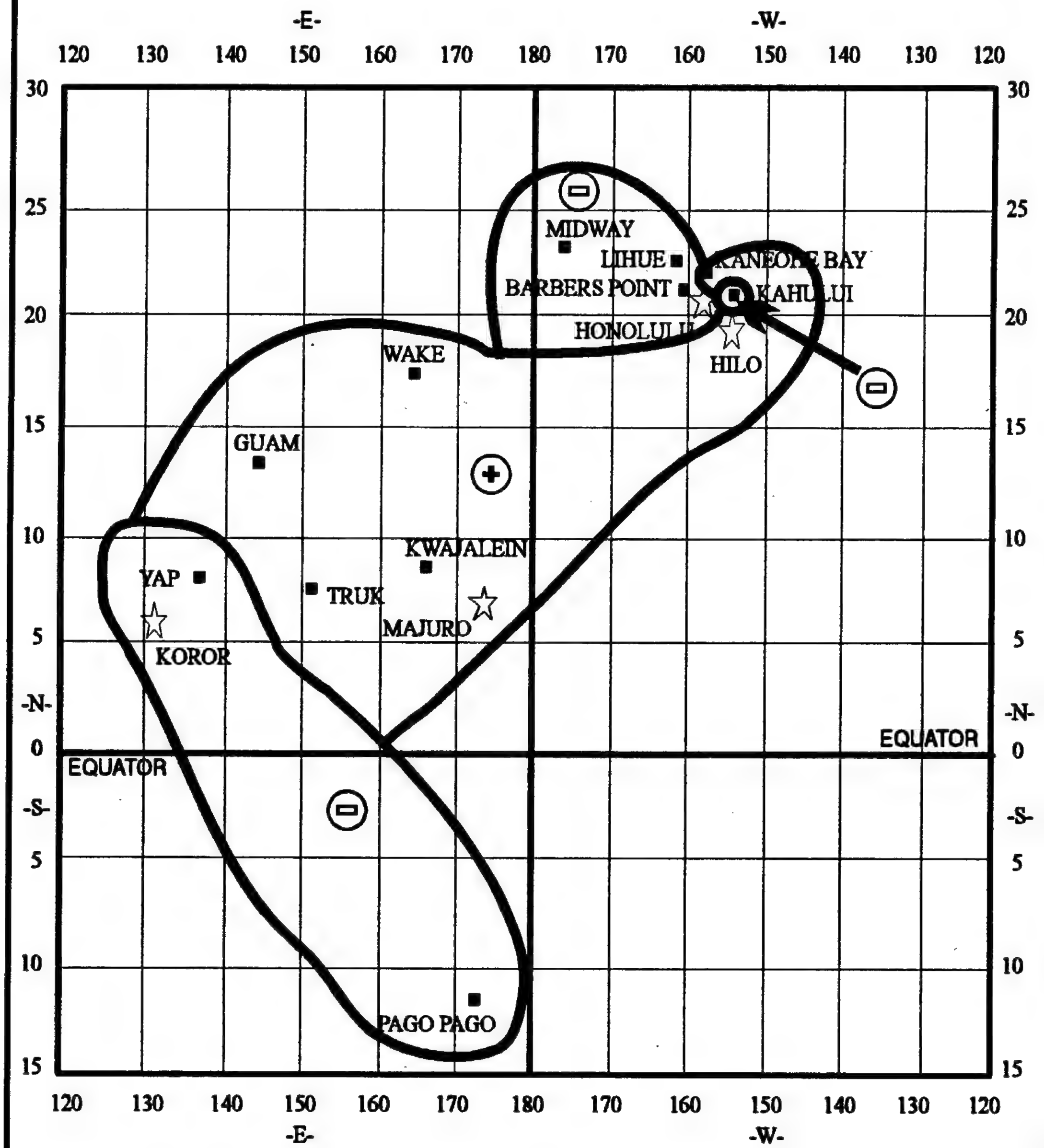

FIGURE 35. PACIFIC ISLANDS TEMPERATURE FREQUENCY GROUP SKEWNESS FOR JANUARY

(+) = POSITIVE SKEW (−) = NEGATIVE SKEW

☐ = VALUES >/= 0.3 OR </= -0.3

climate area of southern California. Like December, high negative skewness persists north of about 45 °N latitude along the Pacific coast, in Florida, and in areas of the central U.S. Rockies. It is interesting to note that the two regions comprising Group 26 have positive skewness. This would provide further evidence of the role of the Great Lakes in modifying the thermal environmental of downwind areas.

Groups 25 and 30, representing the steppe (Bsk) climate, have a slight positive skewness, which may reflect chinook winds common on the leeward slopes of the Rockies.

Skewness for the Pacific islands is negative for the northernmost and southernmost groups. The northernmost group, Group 16, has the largest negative skew (-0.26), which as was in December, can be attributed to the passing cyclones from more northerly latitudes.

January group means for the attribute variables appear in Table 14, group mean normalized temperatures in Table 15, discriminant functions in Table 16, curve-fitting equations in Table 17, and percent probabilities by frequency level in Table 18.

February -- Like January, temperatures in February can be severely cold. Roughly 21 of the 50 states have experienced their extreme minimum temperatures during February (Changery, 1995). Figure 36 shows the February temperature frequency group patterns for North America and Figure 37 shows the same for the islands in the Pacific Ocean. February is comprised of 32 groups.

The patterns of February are quite similar to those of December and January. The eastern half of the U.S. and far eastern Canada again shows a southwest-to- northeast trend. The characteristic patterns of the southeast U.S. closely approximate the Continentality banding of Figure 12. Group 3 represents the Cfa/Dfa and Bsk (steppe) boundary. The Pacific coast of the U.S. and Canada is once again divided into the more southerly Mediterranean climate type and the more northerly Marine West Coast climate type. Patterns in Canada (Groups 21,16,19) still maintain the northwest to southeast configuration. The group patterns of the Pacific islands are latitudinal in nature and quite similar to the December and January patterns.

Figures 38 and 39 show the group mean February skewness for North America and the Pacific islands, respectively. Skewness still remains strongly positive in the High Arctic and along coastal California. Further north along the coast, the groups are strongly negative, again reminiscent of January's patterns. Positive patterns also are beginning to appear up and down the coasts of the eastern U.S. and Canada, perhaps indicative of a strengthening of the flow of maritime tropical air from the Gulf of Mexico. A strong negative pattern still resides over the Florida Keys.

Table 14. Group Means for January

Group	Station Count	Latitude	Elevation	P/E	Continentality	Temperature Range Monthly	Temperature Range Daily	Normalized Mean Daily Max Temp	Normalized Mean Daily Min Temp
1	9	40.14	5199	27.7	43.5	91.9	22.4	70.5	46.1
2	2	53.74	104	338.0	11.8	67.5	12.5	68.0	49.2
3	11	33.67	191	83.2	34.8	81.9	21.6	68.0	41.5
4	6	27.44	31	67.8	17.0	63.3	20.0	77.4	45.9
5	5	44.78	412	104.7	46.8	80.8	15.8	65.8	46.2
6	3	42.86	151	122.4	41.7	90.0	19.3	63.3	41.8
7	5	46.54	336	176.6	33.4	70.8	14.2	61.5	41.4
8	2	11.91	27	158.6	-9.2	22.0	11.5	79.6	27.3
9	22	40.20	542	89.4	43.4	90.4	16.5	61.3	43.0
10	5	72.25	128	21.3	42.2	93.0	13.0	49.7	35.8
11	5	33.99	1669	7.2	40.3	69.2	25.8	70.2	32.9
12	6	35.74	36	31.0	34.0	41.1	35.1	44.2	29.9
13	3	53.64	62	157.0	10.8	54.3	9.7	65.6	47.8
14	7	45.46	1543	46.7	55.3	98.0	19.9	61.2	40.9
15	4	47.75	3670	33.2	39.2	97.8	19.3	65.6	45.9
16	4	24.01	43	45.3	3.9	37.3	11.3	75.5	45.1
17	2	43.88	74	161.3	26.3	56.5	11.5	61.0	40.8
18	2	20.40	52	25.9	0.0	40.0	16.5	74.9	33.5
19	4	49.04	2721	44.3	36.1	90.3	14.8	69.4	53.2
20	6	30.71	186	29.3	32.1	72.0	19.8	64.2	36.4
21	10	35.08	999	93.4	37.9	88.6	19.8	66.8	44.1
22	4	37.84	20	33.0	10.8	48.3	14.0	64.6	35.5
23	7	35.79	3762	17.0	39.5	92.4	26.3	71.2	42.7
24	3	47.31	101	73.3	11.9	66.0	11.3	73.2	56.1
25	2	34.57	2243	29.9	45.1	89.0	25.0	60.7	32.5
26	15	41.04	491	95.2	41.6	84.3	14.6	56.4	39.1
27	2	62.45	135	92.9	12.3	69.5	8.0	59.8	48.2
28	5	14.08	57	102.1	-7.4	25.0	9.2	70.8	33.9
29	3	61.22	515	78.2	43.6	83.0	14.7	51.4	33.7
30	4	41.61	3383	32.0	46.3	103.0	25.8	62.3	37.3
31	2	44.48	1182	34.8	30.1	80.0	16.0	64.2	44.1
32	3	35.83	618	56.1	45.6	91.0	19.7	66.6	44.9
33	11	39.47	1059	63.3	51.7	89.6	19.9	60.0	37.8
34	3	60.81	173	53.7	37.6	106.0	15.0	64.9	50.8
35	11	30.34	61	88.9	29.9	74.1	20.0	72.2	45.1
ALL	198	39.32	985	72.6	34.1	79.3	17.8	64.9	41.5

Table 15. Group Mean Normalized Temperatures: January

Group	Frequency Levels																			
	0	0.001	0.005	0.01	0.03	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	0.95	0.97	0.99	0.995	0.999	1.0
1	0	8.44	16.85	20.51	27.67	31.65	37.69	45.41	50.46	54.46	58.04	61.46	65.10	69.11	74.53	78.70	81.33	86.00	88.43	92.73	100
2	0	8.72	14.28	18.07	26.50	30.76	37.27	44.76	50.46	55.32	59.43	63.32	66.46	69.38	73.08	75.61	77.49	81.37	84.14	89.98	100
3	0	9.15	16.54	20.01	25.87	28.88	33.57	39.50	44.18	48.49	52.53	56.84	61.59	67.46	74.47	79.27	82.17	87.41	89.92	94.00	100
4	0	5.80	13.76	17.53	24.94	29.06	36.14	45.50	52.07	57.21	61.52	65.53	69.42	73.62	79.66	84.14	86.59	90.14	91.59	94.38	100
5	0	6.88	14.49	18.05	24.96	28.14	33.53	40.94	46.49	50.70	54.96	59.89	64.83	70.09	76.43	80.20	82.43	86.94	89.51	93.40	100
6	0	7.36	14.21	18.03	24.62	28.19	33.81	40.55	45.55	49.58	53.39	56.99	60.39	64.04	68.73	72.94	75.84	81.79	84.66	90.53	100
7	0	7.80	13.60	16.58	21.30	24.66	29.83	36.67	41.70	46.61	51.32	55.96	60.02	64.17	70.05	75.36	79.53	86.38	89.14	93.93	100
8	0	6.12	13.14	15.75	20.88	24.76	28.99	36.02	40.79	45.38	49.59	54.32	59.64	65.65	72.01	76.08	78.27	80.88	83.60	88.96	100
9	0	6.89	13.84	17.30	23.76	27.33	32.89	39.42	44.33	48.41	51.99	55.42	58.85	63.02	69.22	74.29	77.50	83.57	86.65	92.10	100
10	0	1.61	4.59	6.55	10.79	13.48	17.66	23.52	28.79	33.16	34.84	40.03	46.10	52.65	61.82	70.05	75.03	84.43	87.22	94.40	100
11	0	8.22	13.77	16.85	22.44	25.35	30.06	36.18	40.93	45.13	49.28	53.32	57.62	62.92	69.93	75.29	78.50	83.80	86.33	90.88	100
12	0	8.01	12.95	15.62	20.26	22.78	27.04	32.35	36.26	39.45	42.30	45.02	47.89	51.39	57.26	63.38	67.96	76.54	80.67	86.91	100
13	0	5.18	10.79	14.19	21.67	26.78	32.65	40.66	45.75	50.60	55.50	60.02	64.34	68.19	72.66	75.93	78.41	83.06	85.16	89.90	100
14	0	7.38	12.64	15.21	19.95	22.79	27.78	34.89	40.83	46.19	51.29	56.20	60.61	65.32	70.83	74.87	77.31	81.96	84.54	90.34	100
15	0	4.76	10.05	12.82	18.08	21.42	27.83	37.56	46.05	53.05	58.52	63.27	67.43	71.75	76.81	80.53	82.58	86.73	89.22	94.16	100
16	0	11.29	19.01	22.47	28.85	32.05	37.50	44.21	49.03	53.06	56.91	60.86	64.58	68.63	73.70	77.23	79.85	83.22	85.98	89.90	100
17	0	7.10	12.12	15.29	21.70	24.95	30.14	37.35	42.43	47.12	51.40	55.34	59.22	63.58	69.21	74.02	77.12	82.45	84.67	89.31	100
18	0	7.51	14.02	16.95	22.34	25.54	30.49	37.05	41.65	45.76	50.03	54.67	59.56	64.54	70.47	74.41	76.46	80.52	81.88	86.66	100
19	0	7.49	16.01	19.74	26.66	31.02	38.08	47.28	54.13	59.23	63.21	66.93	70.58	74.04	78.01	81.16	83.03	86.49	88.45	92.30	100
20	0	6.68	12.05	15.13	20.60	23.64	28.83	34.87	39.41	43.85	48.30	52.69	57.43	62.76	68.80	73.67	76.71	81.96	84.70	89.80	100
21	0	9.22	17.54	21.66	28.41	31.83	36.77	42.60	46.69	50.21	53.67	57.44	61.47	66.34	72.84	77.57	80.37	85.14	87.78	92.32	100
22	0	8.18	13.31	16.25	21.70	24.98	29.78	35.67	40.00	43.91	47.66	51.23	55.06	59.43	65.08	69.85	73.16	78.82	82.29	89.40	100
23	0	10.52	18.74	22.55	29.04	32.68	37.85	43.94	48.15	51.82	55.27	58.92	62.94	67.73	74.12	78.84	81.55	86.39	88.96	93.07	100
24	0	15.59	27.90	31.47	37.86	41.42	46.99	53.34	57.40	60.80	63.95	67.03	70.00	73.00	76.41	79.60	81.94	85.83	87.99	91.87	100
25	0	2.12	7.01	9.50	15.26	18.41	23.50	30.37	35.52	40.06	44.15	48.33	52.55	57.75	65.72	71.44	74.90	81.34	84.60	91.55	100
26	0	5.00	11.32	14.79	20.98	24.21	29.37	35.65	40.33	44.26	47.68	50.89	54.01	57.43	62.45	67.49	71.18	78.30	82.07	88.79	100
27	0	4.15	6.32	9.14	15.15	21.73	33.22	40.15	45.31	50.16	54.92	59.29	63.24	67.90	73.90	79.50	82.60	88.62	91.81	95.75	100
28	0	9.87	16.28	20.00	24.50	27.23	31.58	36.06	39.59	42.57	45.50	48.71	52.31	56.81	62.72	67.18	69.56	73.91	76.90	81.36	100
29	0	1.47	5.02	6.57	10.59	13.33	18.25	23.77	28.47	33.10	38.49	43.19	49.13	56.29	67.77	75.66	80.73	88.71	91.77	96.32	100
30	0	6.94	11.60	14.09	19.50	22.55	27.71	35.44	41.22	45.78	49.68	53.22	56.83	60.92	66.87	71.96	75.30	81.22	84.45	89.88	100
31	0	7.87	15.88	20.14	27.36	31.33	36.91	43.07	46.97	50.02	53.01	55.87	58.76	62.30	67.81	72.43	75.18	80.16	83.13	89.93	100
32	0	13.02	18.71	21.14	26.86	30.01	35.13	41.26	46.03	50.35	54.66	58.80	63.20	68.01	73.93	77.95	80.30	85.46	88.28	92.60	100
33	0	4.45	9.31	11.96	17.55	20.89	26.17	33.47	39.49	44.46	48.80	52.64	56.56	61.15	67.30	72.59	75.93	81.66	84.88	90.66	100
34	0	6.60	12.18	15.88	21.95	25.41	31.56	40.55	47.35	53.22	58.87	64.25	69.58	75.05	80.63	84.05	85.97	89.60	91.27	94.77	100
35	0	6.37	15.54	19.72	26.47	29.65	34.95	41.95	47.34	52.30	57.21	62.08	67.02	72.30	78.24	82.36	85.01	89.11	90.87	93.69	100

Table 16. Discriminant Function Values: January

Function value = (a x lat) + (b x elev) + (c x P/E) + (d x K) + (e x mrange) + (f x drange) + (g x nmax) + (h x nmin) + constant

Group	a	b	c	d	e	f	g	h	constant
1	8.034	0.028	0.130	2.097	7.732	-32.484	37.270	-25.590	-997.86
2	11.835	-0.013	1.532	-0.750	8.680	-34.878	39.025	-27.954	-1289.42
3	8.387	-0.014	0.278	0.904	8.518	-32.589	37.041	-26.303	-880.11
4	8.210	-0.014	0.180	0.107	8.809	-36.067	40.600	-28.451	-960.26
5	9.302	-0.011	0.390	1.628	8.839	-35.791	38.577	-27.354	-979.75
6	9.336	-0.015	0.472	1.033	9.104	-34.407	37.573	-27.277	-948.39
7	9.789	-0.011	0.769	0.803	8.590	-34.970	37.792	-27.552	-957.11
8	7.234	-0.005	0.651	-0.709	15.499	-73.833	67.421	-56.607	-1757.76
9	8.551	-0.012	0.292	1.197	9.579	-37.217	38.211	-28.040	-904.87
10	12.348	-0.025	0.027	0.103	11.140	-41.043	40.659	-31.081	-1155.30
11	8.229	0.001	0.028	1.860	7.971	-33.230	39.682	-28.691	-949.91
12	8.289	-0.017	-0.022	-1.035	9.542	-37.278	38.679	-29.501	-793.14
13	11.103	-0.016	0.654	-0.760	8.447	-34.699	37.901	-26.365	-1022.48
14	8.894	-0.005	0.141	2.002	9.236	-35.664	38.043	-27.698	-956.58
15	9.181	0.011	0.100	1.118	9.307	-36.658	38.976	-27.800	-1008.39
16	7.515	-0.011	0.062	-0.357	9.766	-44.226	44.822	-32.676	-982.27
17	9.416	-0.011	0.695	0.557	8.238	-34.903	37.400	-27.130	-892.15
18	7.304	-0.007	0.072	-0.062	7.754	-37.086	41.996	-30.426	-899.66
19	9.537	0.003	0.099	0.866	9.602	-38.818	40.237	-28.026	-1057.45
20	7.700	-0.013	0.031	0.875	8.753	-34.683	37.737	-27.559	-814.91
21	8.236	-0.007	0.323	1.087	8.943	-34.734	37.678	-26.984	-894.84
22	8.967	-0.015	0.068	-0.444	9.557	-40.245	41.872	-31.263	-918.32
23	7.995	0.014	0.052	1.639	7.512	-29.344	35.747	-24.362	-920.10
24	10.321	-0.018	0.174	-0.830	9.091	-36.212	38.902	-26.020	-1036.95
25	7.651	0.003	0.115	1.795	7.928	-30.382	35.127	-25.658	-803.71
26	8.458	-0.011	0.340	1.124	9.499	-37.405	37.639	-28.212	-851.99
27	11.788	-0.021	0.316	-1.316	9.747	-37.487	38.253	-27.116	-1054.88
28	6.419	-0.007	0.256	-0.795	11.724	-54.814	51.390	-40.900	-1083.13
29	10.998	-0.015	0.334	0.841	9.639	-36.964	38.372	-29.109	-992.45
30	8.438	0.009	0.130	1.650	8.256	-30.642	35.415	-25.433	-895.34
31	9.208	-0.009	0.055	0.405	9.281	-36.435	38.417	-27.433	-918.14
32	8.140	-0.011	0.128	1.501	9.022	-34.872	37.615	-26.699	-904.18
33	8.239	-0.006	0.223	1.959	8.751	-34.184	36.881	-27.045	-868.10
34	11.594	-0.025	0.077	-0.136	11.794	-43.389	43.143	-31.513	-1253.20
35	8.147	-0.013	0.286	0.785	8.499	-33.834	38.147	-26.715	-901.47

INPUT VARIABLES
lat = latitude
elev = elevation
P/E = Precipitation Effectiveness Index
K = Continentality
mrange = monthly temperature range
drange = daily temperature range
nmax = normalized mean daily maximum temperature
nmin = normalized mean daily minimum temperature

Table 17. Temperature Frequency Equations: January

Group	If Input Normalized Temperature (T) < 50th Percentile Normalized Temperature (T)	Maximum Error E1	Maximum Error E2	50th Percentile Normalized T	Group	If Input Normalized Temperature (T) > 50th Percentile Normalized Temperature (T)	Maximum Error E3	Maximum Error E4
1	F=-0.0012+0.00137746*T^1-0.000134483*T^2+4.4739E-006*T^3	0.002	0.003	58.04	1	F=-5.4800+0.188618*T-0.00180695*T^2+5.68375E-006*T^3	0.008	0.006
2	F=0.0015+5.47571E-006*T^1-3.86457E-005*T^2+3.04286E-006*T^3	0.002	0.005	59.43	2	F=34.8478-1.96218*T+0.040506*T^2-0.000358521*T^3+1.15833E-006*T^4	0.009	0.010
3	F=0.0044-0.0014833*T^1+2.52517E-006*T^2+3.98454E-006*T^3	0.006	0.012	52.53	3	F=-1.9765+0.0707217*T-0.000493846*T^2+8.38598E-007*T^3	0.005	0.009
4	F=0.0004-7.43574E-005*T^1-2.3102E-006*T^2+2.2004E-006*T^3	0.001	0.001	61.52	4	F=-3.3175+0.0953964*T-0.000577484*T^2+5.49106E-007*T^3	0.008	0.004
5	F=0.0029-0.000929696*T^1+9.17834E-006*T^2+3.173E-006*T^3	0.004	0.007	54.96	5	F=-1.0297+0.025463*T+0.000155036*T^2-2.07477E-006*T^3	0.007	0.009
6	F=0.0015+6.64545E-006*T^1-6.02918E-005*T^2+4.43876E-006*T^3	0.002	0.005	53.39	6	F=-5.6634+0.213696*T-0.00227538*T^2+8.04436E-006*T^3	0.015	0.005
7	F=0.0057-0.00316896*T^1+0.000178256*T^2+1.45274E-006*T^3	0.008	0.008	51.32	7	F=-3.2463+0.123492*T-0.00117861*T^2+3.67743E-006*T^3	0.017	0.006
8	F=0.0050-0.00255016*T^1+0.000132152*T^2+2.49375E-006*T^3	0.006	0.010	49.59	8	F=-1.0302+0.0358847*T-5.03723E-005*T^2-1.05978E-006*T^3	0.008	0.010
9	F=0.0014+2.43563E-005*T^1-6.13605E-005*T^2+4.74857E-006*T^3	0.002	0.004	51.99	9	F=-4.6906+0.181662*T-0.00193212*T^2+6.84488E-006*T^3	0.008	0.002
10	F=-0.0008+0.00018042*T^1+0.000217313*T^2+4.9764E-006*T^3	0.002	0.020	34.84	10	F=-0.7351+0.0501164*T-0.000476696*T^2+1.48805E-006*T^3	0.008	0.003
11	F=0.0049-0.00229361*T^1+8.83241E-005*T^2+3.37297E-006*T^3	0.007	0.009	49.28	11	F=-2.6107+0.104271*T-0.000987738*T^2+3.05856E-006*T^3	0.004	0.004
12	F=0.0013+2.5682E-005*T^1-0.00011492*T^2+9.34237E-006*T^3	0.002	0.003	42.30	12	F=-3.5411+0.16733*T-0.00204117*T^2+8.225E-006*T^3	0.015	0.015
13	F=0.0038-0.00110702*T^1+5.21766E-005*T^2+2.37803E-006*T^3	0.004	0.010	55.50	13	F=-3.2071+0.105698*T-0.000793959*T^2+1.56893E-006*T^3	0.002	0.002
14	F=0.0061-0.00408982*T^1+0.000284539*T^2-2.91691E-007*T^3	0.009	0.007	51.29	14	F=-2.2391+0.0805786*T-0.000591203*T^2+1.08548E-006*T^3	0.015	0.015
15	F=0.0013-0.00164237*T^1+0.000194826*T^2-3.79479E-007*T^3	0.003	0.005	58.52	15	F=-1.8150+0.0439729*T+3.4144E-005*T^2-1.93414E-006*T^3	0.014	0.014
16	F=0.0013+0.000469085*T^1-0.00010817*T^2+4.49894E-006*T^3	0.002	0.006	56.91	16	F=-4.2989+0.145027*T-0.00126859*T^2+3.47696E-006*T^3	0.012	0.013
17	F=0.0043-0.00189524*T^1+9.6051E-005*T^2+2.54997E-006*T^3	0.005	0.008	51.40	17	F=-3.7607+0.14428*T-0.00144346*T^2+4.76411E-006*T^3	0.010	0.006
18	F=0.0043-0.00192478*T^1+6.68923E-005*T^2+3.47449E-006*T^3	0.005	0.008	50.03	18	F=-1.7140+0.0621959*T-0.000373648*T^2+2.26393E-007*T^3	0.012	0.010
19	F=-0.0002+0.000153989*T^1-2.44591E-005*T^2+2.31386E-006*T^3	0.001	0.003	63.21	19	F=-4.7876+0.135244*T-0.000897804*T^2+1.23348E-006*T^3	0.012	0.013
20	F=0.0061-0.00295462*T^1+0.000158442*T^2+2.46973E-006*T^3	0.007	0.013	48.30	20	F=-2.1812+0.0874532*T-0.000766279*T^2+2.09366E-006*T^3	0.010	0.009
21	F=-0.0002+0.00191104*T^1-0.000221385*T^2+6.74889E-006*T^3	0.004	0.008	53.67	21	F=-3.4724+0.126714*T-0.00117296*T^2+3.52744E-006*T^3	0.005	0.005
22	F=0.0033-0.00120211*T^1+8.07278E-006*T^2+5.03398E-006*T^3	0.004	0.009	47.66	22	F=-3.6102+0.150362*T-0.0016285*T^2+5.8571E-006*T^3	0.009	0.004
23	F=-0.0003+0.00192233*T^1-0.000211167*T^2+6.19139E-006*T^3	0.003	0.006	55.27	23	F=-3.7573+0.133213*T-0.00121724*T^2+3.60531E-006*T^3	0.004	0.004
24	F=-0.0030+0.00462309*T^1-0.000324649*T^2+5.86168E-006*T^3	0.011	0.009	63.95	24	F=-11.1974+0.367788*T-0.00366966*T^2+1.21101E-005*T^3	0.018	0.010
25	F=0.0037-0.00216605*T^1+0.000237368*T^2+1.54443E-006*T^3	0.004	0.004	44.15	25	F=-2.1625+0.0979889*T-0.00100835*T^2+3.4456E-006*T^3	0.007	0.001
26	F=0.0020-0.000460498*T^1-2.06263E-005*T^2+5.26544E-006*T^3	0.003	0.004	47.68	26	F=-4.8652+0.204794*T-0.00237436*T^2+9.13103E-006*T^3	0.011	0.007
27	F=-0.0015+0.00160542*T^1-5.89235E-005*T^2+3.63003E-006*T^3	0.008	0.012	54.92	27	F=-3.3590+0.118207*T-0.00103438*T^2+2.87673E-006*T^3	0.013	0.006
28	F=0.0006+0.00207753*T^1-0.000309627*T^2+1.11964E-005*T^3	0.004	0.008	45.50	28	F=-3.4407+0.150126*T-0.00168273*T^2+6.25455E-006*T^3	0.004	0.004
29	F=0.0067-0.00490461*T^1+0.00070287*T^2-6.18818E-006*T^3	0.006	0.014	38.49	29	F=-0.9230+0.054636*T-0.000522548*T^2+1.68648E-006*T^3	0.002	0.001
30	F=0.0019-0.00151911*T^1+0.000114621*T^2+2.3733E-006*T^3	0.003	0.003	49.68	30	F=-4.1589+0.167308*T-0.00180554*T^2+6.48231E-006*T^3	0.008	0.002
31	F=-0.0043+0.00383387*T^1-0.000327788*T^2+8.20348E-006*T^3	0.008	0.006	53.01	31	F=-6.5514+0.253519*T-0.00283217*T^2+1.05221E-005*T^3	0.007	0.001
32	F=0.0032-0.00135018*T^1-1.81417E-006*T^2+3.59911E-006*T^3	0.007	0.011	54.66	32	F=-2.8279+0.0967279*T-0.000747148*T^2+1.6201E-006*T^3	0.010	0.009
33	F=0.0039-0.00231244*T^1+0.00020634*T^2+1.02881E-006*T^3	0.003	0.004	48.80	33	F=-3.3480+0.135936*T-0.00141032*T^2+4.85526E-006*T^3	0.008	0.003
34	F=0.0048-0.00249164*T^1+0.000166261*T^2+3.44507E-007*T^3	0.005	0.004	58.87	34	F=1.5159-0.0795203*T+0.00150663*T^2-7.63766E-006*T^3	0.009	0.010
35	F=0.0063-0.00240834*T^1+8.2816E-005*T^2+1.9845E-006*T^3	0.008	0.011	57.21	35	F=-0.7271+0.00971293*T+0.000375801*T^2-3.00844E-006*T^3	0.008	0.008

E1 = Maximum Prediction Error When Computed Frequency < 5%
E2 = Maximum Prediction Error When Computed Frequency Between 5 - 50%
E3 = Maximum Prediction Error When Computed Frequency Between 50 - 95%
E4 = Maximum Prediction Error When Computed Frequency >95%

Table 18. Percent Probability of Predicted Temperatures >2.0C at Each Frequency Level by Group

Month: January

	STANDARDIZED FREQUENCY LEVELS																		% OF ALL >
GROUP	0.001	0.005	0.01	0.03	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	0.95	0.97	0.99	0.995	0.999	2.0C
1	22	55	55	67	67	44	33	33	33	44	44	44	0	0	0	0	0	0	0	28.7
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
3	18	18	18	9	9	9	9	9	9	9	9	9	0	0	0	0	0	0	0	7.2
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
5	20	20	20	20	20	0	0	0	0	0	0	20	40	20	0	0	0	0	0	15.8
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
7	0	0	0	0	0	0	0	0	0	0	0	20	20	20	0	0	0	0	0	3.2
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
9	18	23	23	9	9	14	9	0	0	0	0	0	0	9	14	14	9	9	0	8.4
10	0	0	0	0	0	0	40	40	60	60	60	60	60	40	80	60	0	40	0	31.6
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	0	0	1.0
12	17	17	17	17	17	17	0	0	0	0	0	0	0	0	0	0	0	0	0	5.3
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	33	33	33	33	0	7.0
14	22	11	11	22	33	33	11	11	11	11	22	22	33	44	44	33	33	22	11	23.4
15	0	25	50	50	50	50	50	25	0	25	25	25	50	25	25	0	0	0	0	25.0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
19	0	0	0	0	0	0	0	0	0	0	0	0	25	75	75	50	50	50	25	17.1
20	0	0	0	0	0	0	0	0	0	33	33	33	50	33	0	0	0	0	0	9.6
21	0	0	0	0	0	0	0	0	0	0	0	10	10	10	0	0	0	0	0	1.6
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
23	14	29	43	14	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6.0
24	33	33	33	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.7
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
29	0	0	0	0	0	0	0	0	0	33	0	0	0	0	0	0	0	0	0	1.8
30	0	25	25	25	25	25	25	25	25	25	25	25	25	25	0	0	0	0	0	17.6
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
32	0	0	0	0	0	0	0	0	33	33	33	33	0	0	0	0	0	0	0	7.0
33	0	0	0	0	0	0	0	0	0	11	11	11	11	22	11	11	11	11	11	6.4
34	33	33	0	33	33	0	0	33	33	66	66	66	66	33	0	0	0	0	0	26.0
35	27	9	9	18	18	18	27	27	27	27	27	18	9	0	0	0	0	9	0	14.0

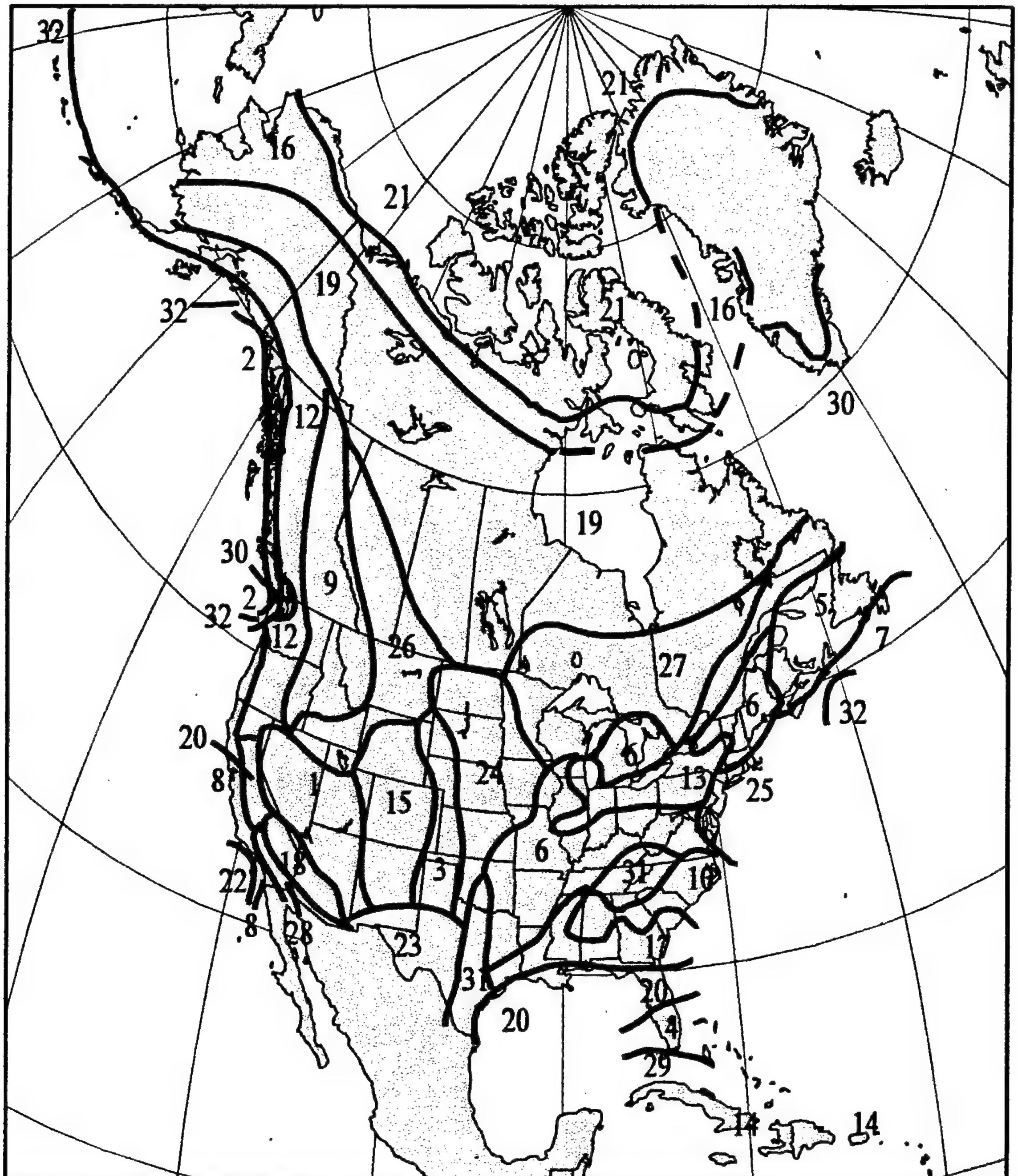

FIGURE 36.NORTH AMERICA TEMPERATURE FREQUENCY GROUPS FOR FEBRUARY

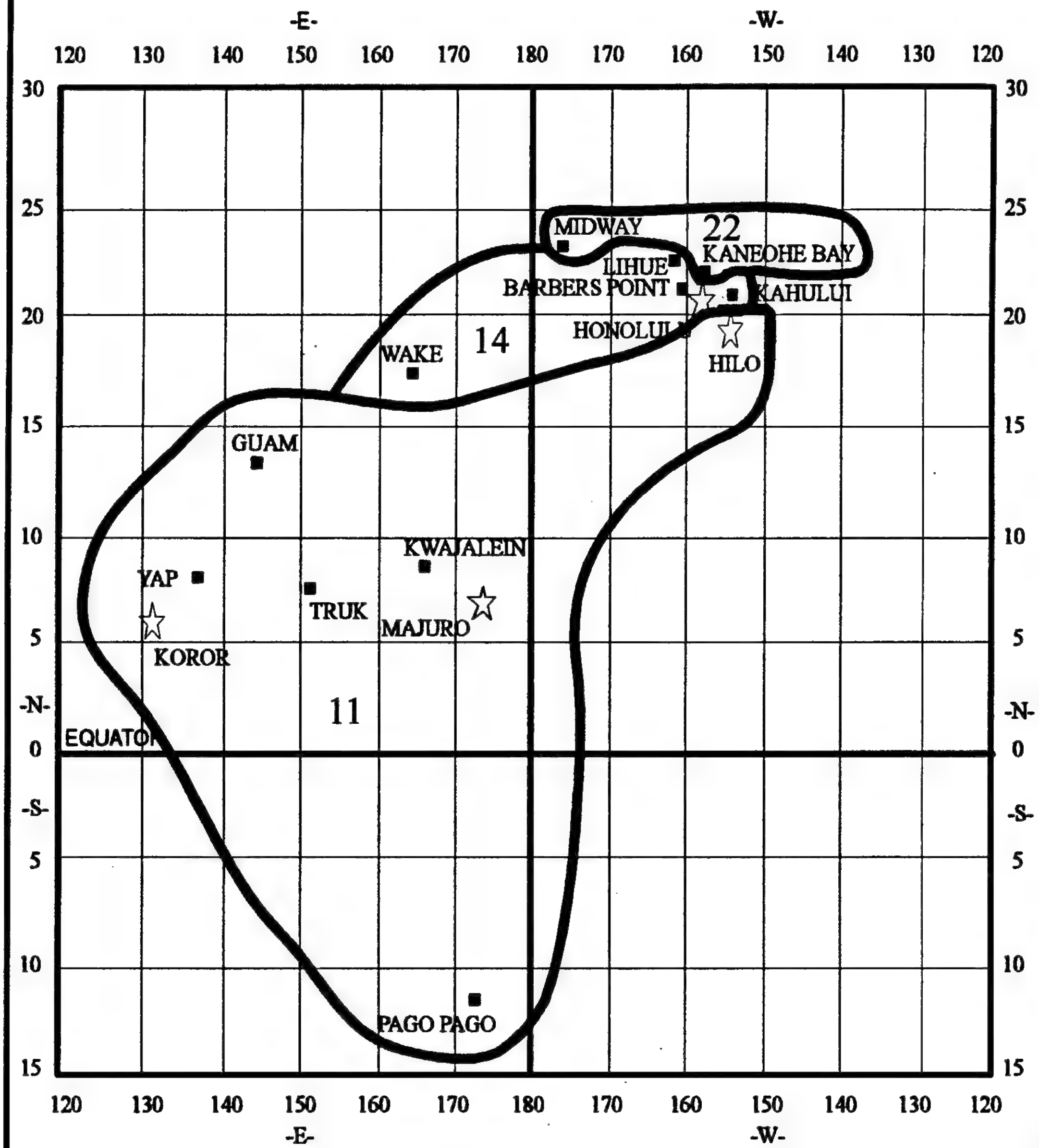

FIGURE 37. PACIFIC ISLANDS TEMPERATURE FREQUENCY GROUPS FOR FEBRUARY

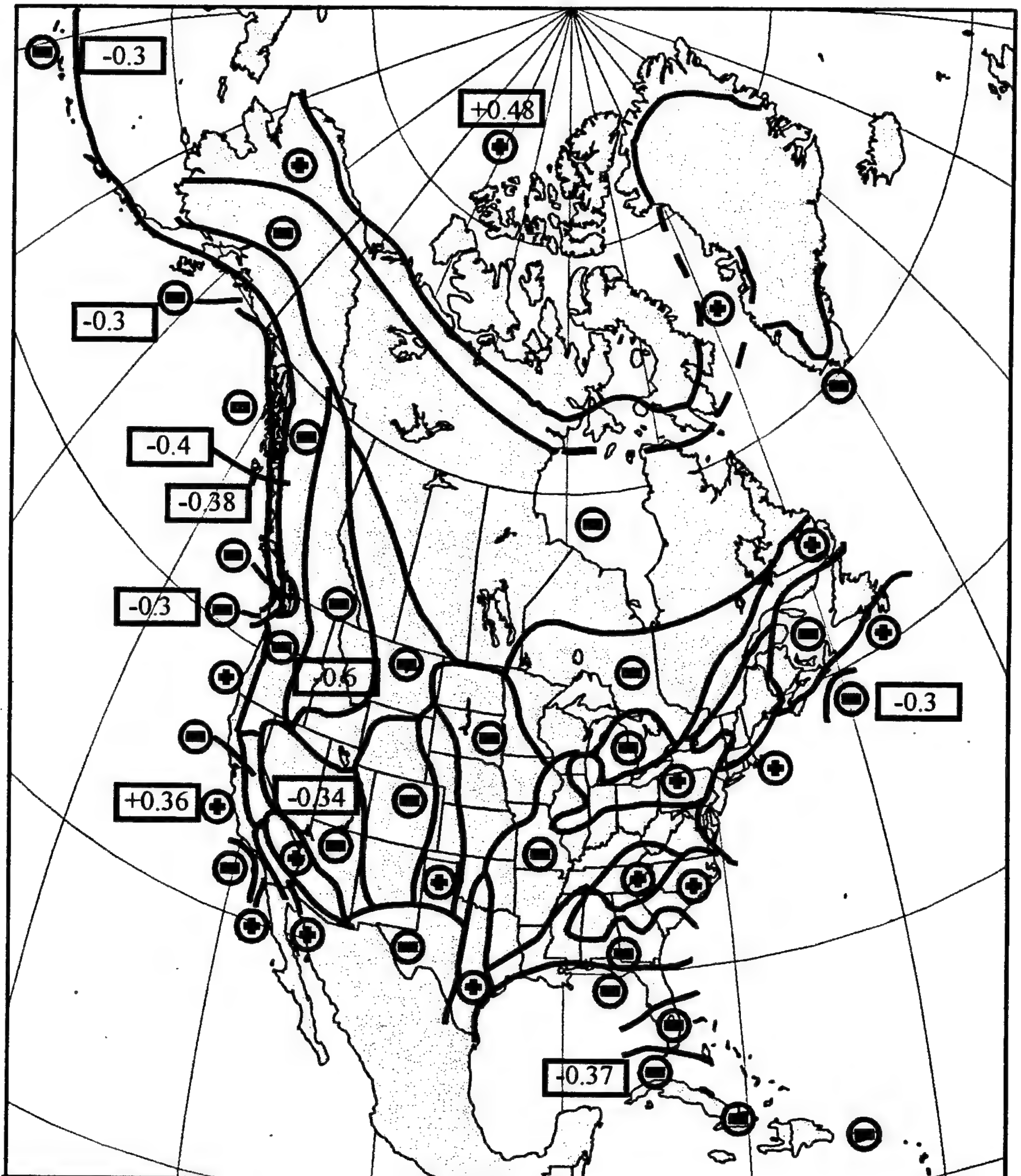

FIGURE 38. NORTH AMERICA TEMPERATURE FREQUENCY GROUP SKEWNESS FOR FEBRUARY

⊕ = POSITIVE SKEW ⊖ = NEGATIVE SKEW

☐ = VALUES >/= 0.3 OR </= -0.3

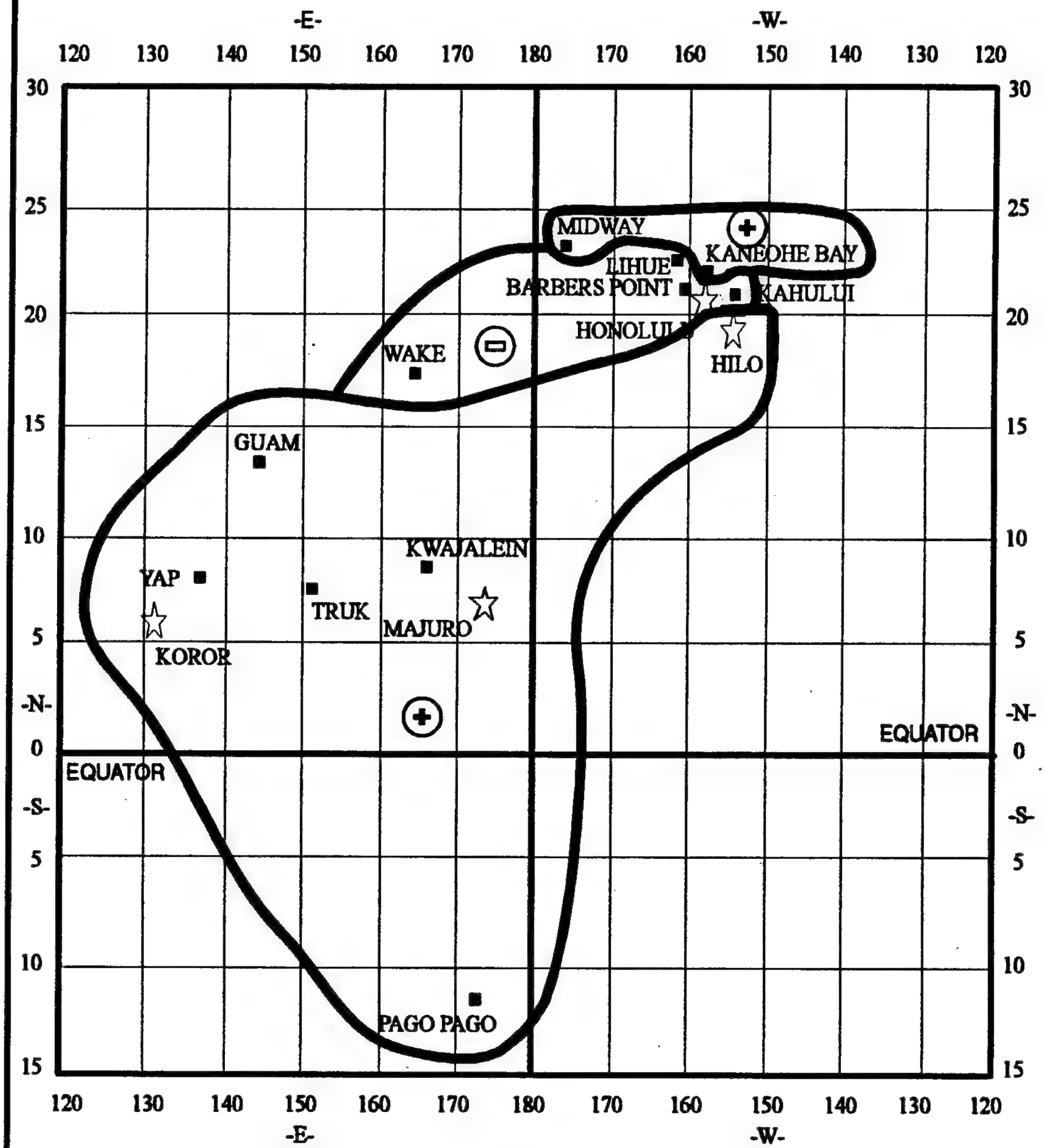

FIGURE 39. PACIFIC ISLANDS TEMPERATURE FREQUENCY GROUP SKEWNESS FOR FEBRUARY

(+) = POSITIVE SKEW (−) = NEGATIVE SKEW

☐ = VALUES >/= 0.3 OR </= -0.3

Table 19. Group Means for February

Group	Station Count	Latitude	Elevation	P/E	Continentality	Temperature Range Monthly	Temperature Range Daily	Normalized Mean Daily Max Temp	Normalized Mean Daily Min Temp
1	6	40.27	4417	20.1	41.3	97.8	25.3	71.9	46.0
2	2	53.74	104	338.0	11.8	67.5	14.0	68.3	47.4
3	4	40.58	3042	33.1	47.5	101.0	25.0	62.8	38.1
4	4	26.76	16	69.5	15.1	58.8	19.3	75.8	43.0
5	5	45.78	271	169.3	33.3	67.8	14.6	63.6	42.0
6	12	40.33	558	96.2	44.3	91.6	18.6	64.5	44.0
7	1	47.62	459	197.3	27.4	70.0	12.0	55.7	38.5
8	6	34.94	40	22.4	6.3	55.5	17.5	59.2	27.7
9	4	46.44	3241	41.4	37.1	89.5	16.8	74.2	55.5
10	10	33.46	272	84.2	35.1	74.8	22.2	64.3	34.6
11	5	10.70	62	147.9	-9.9	22.8	10.4	75.6	29.7
12	4	49.16	508	72.0	30.0	86.5	18.3	72.0	50.8
13	19	42.86	611	94.0	44.6	83.6	15.7	59.4	40.7
14	5	20.68	50	34.0	-1.0	34.2	14.4	75.3	33.2
15	5	39.52	5638	27.5	41.7	92.4	24.4	68.8	42.2
16	3	64.79	529	51.5	36.9	88.3	14.3	57.4	41.2
17	12	31.89	209	90.7	33.0	75.8	22.0	70.5	41.5
18	4	34.33	2035	8.3	40.7	72.5	26.8	66.8	30.0
19	4	56.14	965	41.5	54.6	101.8	22.3	63.6	41.7
20	8	30.90	29	71.5	26.6	62.0	20.0	69.5	37.2
21	4	73.30	36	26.8	40.8	85.0	11.0	45.2	32.3
22	5	30.63	54	32.2	3.8	40.0	11.0	60.5	32.7
23	5	32.41	3120	19.4	41.5	90.8	28.6	71.2	39.4
24	13	41.08	1204	56.9	53.4	98.2	20.3	61.1	40.4
25	13	39.65	192	97.6	39.9	79.7	16.5	57.4	36.7
26	7	47.36	3414	34.3	42.4	97.0	19.9	67.4	46.9
27	3	45.84	775	64.7	52.9	84.3	17.0	64.8	44.6
28	5	32.05	235	18.8	33.7	70.0	22.8	63.1	30.1
29	1	24.55	4	47.2	11.0	39.0	10.0	76.9	51.2
30	5	57.50	110	86.7	10.7	61.4	9.4	62.2	46.6
31	11	35.07	988	72.7	36.7	80.1	20.8	64.3	38.2
32	3	46.42	9	166.4	15.6	55.7	11.3	65.8	45.5
ALL	198	39.32	985	72.6	34.1	74.2	17.9	65.6	40.3

Table 20. Group Mean Normalized Temperatures: February

	Frequency Levels																				
Group	0	0.001	0.005	0.01	0.03	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	0.95	0.97	0.99	0.995	0.999	1.0
1	0	10.10	20.69	25.46	33.07	36.89	42.15	48.05	51.95	55.20	58.06	61.02	64.32	68.30	74.03	78.64	81.48	86.24	88.58	93.36	100
2	0	5.80	14.13	18.65	27.60	31.93	39.17	46.76	51.65	55.52	58.82	61.69	64.13	66.84	70.21	73.20	75.51	80.55	83.74	89.07	100
3	0	4.60	11.35	14.66	21.39	24.90	30.42	36.80	41.57	45.52	48.83	52.20	55.75	60.40	67.69	73.65	77.12	83.25	86.69	92.46	100
4	0	6.55	12.10	15.62	22.83	27.28	34.29	43.31	49.91	54.92	59.16	62.90	66.76	70.98	76.93	81.14	83.43	87.16	88.88	92.03	100
5	0	4.41	11.42	14.49	20.53	24.13	30.25	38.51	44.32	49.76	54.56	58.95	62.69	66.31	71.84	77.14	80.56	86.02	88.13	92.28	100
6	0	9.05	15.77	18.92	25.21	28.75	34.81	42.04	46.75	50.50	53.92	57.14	60.60	64.75	70.84	75.83	79.02	84.70	87.63	93.25	100
7	0	3.08	6.51	9.49	16.56	21.09	26.86	33.24	39.10	43.60	47.72	51.21	53.33	56.53	62.51	69.74	73.79	81.36	85.31	92.90	100
8	0	5.66	10.67	13.04	17.79	20.36	24.84	30.58	34.66	37.95	40.86	43.75	46.88	50.70	56.65	62.66	66.71	74.76	79.22	87.03	100
9	0	10.55	19.15	25.50	36.43	41.33	48.08	55.34	59.81	62.99	65.61	67.99	70.45	73.15	77.05	80.62	83.06	87.65	90.42	94.73	100
10	0	4.60	9.84	12.61	18.16	21.34	26.35	32.84	37.96	42.59	47.07	51.85	57.00	62.75	69.50	74.68	77.94	83.61	86.29	91.71	100
11	0	11.19	18.75	21.55	25.97	29.11	33.42	38.05	41.90	45.16	48.42	52.42	57.02	62.43	68.64	72.76	74.63	78.80	81.71	86.29	100
12	0	8.52	20.21	24.76	32.64	36.52	41.75	47.87	52.93	57.42	61.68	65.50	69.38	73.21	77.86	81.09	83.12	86.84	89.05	93.27	100
13	0	6.31	12.12	15.45	21.13	24.44	29.88	36.87	41.68	45.88	49.76	53.50	57.27	61.25	66.90	71.84	75.18	81.42	84.72	91.44	100
14	0	5.84	12.82	15.80	22.12	25.49	31.12	37.12	41.74	45.76	49.76	53.98	58.56	63.77	70.15	74.46	77.13	81.93	83.93	88.88	100
15	0	5.55	13.46	17.91	25.90	30.22	36.41	42.97	47.42	50.99	54.45	58.04	61.98	66.66	73.38	78.17	81.00	86.09	88.61	93.05	100
16	0	1.60	5.41	7.37	12.95	16.28	21.51	28.39	34.80	41.41	47.21	52.76	58.75	66.37	76.68	82.14	85.43	91.36	93.20	96.18	100
17	0	7.72	15.45	18.48	24.02	27.28	32.62	39.89	45.35	50.05	54.48	59.04	63.86	68.89	74.90	79.28	81.93	86.52	88.70	93.06	100
18	0	7.45	12.02	14.65	19.96	22.85	27.82	33.94	38.91	43.17	47.15	51.32	55.92	61.24	68.42	73.78	77.02	82.21	85.13	91.36	100
19	0	5.71	10.07	12.30	17.69	20.98	27.33	36.11	42.50	47.80	52.71	57.46	62.27	67.57	74.03	78.52	81.03	85.18	87.47	92.26	100
20	0	4.26	9.05	11.92	17.83	21.45	27.52	35.65	41.83	46.90	51.54	56.14	60.88	66.13	72.93	78.09	81.17	86.28	88.40	92.26	100
21	0	2.12	4.90	7.10	11.64	13.99	18.27	23.54	27.29	31.01	34.74	38.97	43.91	49.14	58.64	67.27	73.30	84.45	88.46	96.11	100
22	0	10.28	15.69	18.01	23.01	25.31	29.57	34.54	38.01	41.08	43.94	46.86	49.99	53.75	59.25	64.41	68.19	75.24	79.10	86.92	100
23	0	11.40	17.78	21.54	27.59	30.62	35.10	40.67	44.90	48.85	52.92	56.99	61.49	66.95	74.15	79.57	82.62	87.72	90.01	94.23	100
24	0	6.91	11.95	15.02	21.12	24.77	30.36	37.16	42.39	46.82	50.62	54.11	57.66	61.63	67.52	72.49	75.82	81.89	85.28	91.61	100
25	0	6.01	11.63	14.50	20.06	23.36	28.48	34.72	39.12	42.72	45.90	49.05	52.52	57.02	64.05	69.98	73.79	80.49	84.15	91.12	100
26	0	4.56	12.15	16.48	23.47	27.24	33.25	42.13	48.93	54.30	58.66	62.45	66.18	70.04	75.42	79.55	82.12	86.81	89.26	93.86	100
27	0	7.05	13.26	16.04	21.90	25.55	31.38	39.37	45.50	51.00	55.79	59.90	64.53	69.24	73.95	77.73	80.05	85.06	87.64	92.70	100
28	0	4.98	8.91	11.59	16.81	19.76	24.46	30.90	35.56	39.78	43.82	48.03	52.34	57.14	63.83	69.37	72.76	78.52	81.61	88.31	100
29	0	8.12	13.89	17.67	26.38	30.88	37.58	45.49	51.13	56.54	61.27	65.86	69.86	73.67	78.82	82.67	84.45	88.27	89.45	93.27	100
30	0	3.52	9.76	14.41	22.83	26.34	32.15	39.17	44.22	49.07	53.82	58.21	62.19	66.77	73.33	77.70	80.34	85.05	86.81	90.66	100
31	0	5.57	12.42	15.90	22.05	25.39	30.44	36.54	41.03	44.93	48.82	52.96	57.57	62.73	69.30	74.41	77.58	83.45	86.44	91.94	100
32	0	6.87	15.15	21.15	29.61	32.72	38.35	45.04	49.56	53.29	56.65	59.77	62.60	65.32	69.35	73.35	75.80	80.85	83.67	89.10	100

Table 21. Discriminant Function Values: February

Function value = (a x lat) + (b x elev) + (c x P/E) + (d x K) + (e x mrange) + (f x drange) + (g x nmax) + (h x nmin) + constant

Group	a	b	c	d	e	f	g	h	constant
1	6.362	0.029	-0.368	2.303	11.702	-31.878	38.832	-21.366	-1312.85
2	6.294	0.002	0.692	0.407	10.930	-30.760	36.631	-21.526	-1186.02
3	5.766	0.019	-0.269	2.724	11.865	-32.351	37.935	-22.580	-1165.19
4	4.980	-0.002	-0.182	1.185	11.329	-34.073	40.001	-23.550	-1086.54
5	5.842	0.001	0.123	2.040	10.797	-31.951	36.716	-21.770	-1024.43
6	5.446	0.002	-0.110	2.712	12.202	-35.007	39.215	-23.522	-1148.64
7	5.549	0.003	0.257	1.505	10.933	-32.377	35.366	-22.078	-930.67
8	5.160	0.000	-0.262	0.511	11.101	-34.207	37.757	-24.556	-878.81
9	6.913	0.022	-0.406	2.150	12.173	-35.703	40.811	-21.939	-1381.66
10	4.948	-0.001	-0.075	2.267	11.016	-31.356	37.131	-22.774	-985.77
11	2.987	0.000	0.164	-0.240	15.311	-53.112	51.814	-38.301	-1321.16
12	6.833	0.003	-0.271	1.844	11.765	-33.766	39.734	-21.787	-1267.08
13	5.504	0.002	-0.116	2.739	11.734	-34.616	37.912	-23.147	-1052.89
14	4.423	-0.001	-0.276	0.362	13.425	-45.272	47.174	-31.954	-1193.42
15	6.213	0.038	-0.319	2.244	11.549	-32.016	38.265	-21.736	-1275.42
16	7.639	0.004	-0.337	2.164	11.967	-35.702	39.090	-23.218	-1198.86
17	5.078	-0.001	-0.093	2.164	11.132	-31.535	38.010	-22.206	-1070.49
18	5.535	0.011	-0.326	2.635	10.806	-30.848	37.994	-23.107	-1064.12
19	7.085	0.004	-0.339	3.318	12.130	-34.042	39.765	-23.126	-1308.93
20	5.031	-0.002	-0.152	1.873	11.148	-33.339	38.960	-23.704	-1026.18
21	7.915	0.001	-0.403	2.398	11.790	-36.431	37.786	-23.926	-1106.14
22	4.851	0.000	-0.276	0.456	10.711	-35.154	37.410	-23.859	-836.22
23	5.551	0.018	-0.306	2.487	11.040	-29.411	37.413	-21.099	-1167.36
24	5.476	0.005	-0.226	3.246	12.369	-35.289	39.213	-23.949	-1162.71
25	5.099	-0.001	-0.063	2.469	11.442	-33.580	36.918	-23.078	-966.13
26	6.652	0.023	-0.362	2.393	12.353	-35.395	40.155	-22.971	-1306.61
27	6.147	0.003	-0.270	3.350	11.587	-34.228	38.845	-22.490	-1179.36
28	4.984	-0.001	-0.285	2.286	11.148	-32.733	38.100	-23.956	-978.75
29	5.031	-0.001	-0.346	1.081	10.445	-34.236	38.692	-21.276	-1038.53
30	7.307	0.003	-0.233	0.615	10.231	-31.462	35.657	-19.451	-1028.97
31	5.158	0.004	-0.139	2.287	11.282	-32.218	37.427	-22.527	-1021.99
32	6.137	0.001	0.086	0.965	10.143	-30.740	35.624	-20.133	-981.76

INPUT VARIABLES
lat = latitude
elev = elevation
P/E = Precipitation Effectiveness Index
K = Continentality
mrange = monthly temperature range
drange = daily temperature range
nmax = normalized mean daily maximum temperature
nmin = normalized mean daily minimum temperature

Table 22. Temperature Frequency Equations: February

Group	If Input Normalized Temperature (T) < 50th Percentile Normalized Temperature (T)	Maximum Error E1	Maximum Error E2	50th Percentile Normalized T	Group	If Input Normalized Temperature (T) > 50th Percentile Normalized Temperature (T)	Maximum Error E3	Maximum Error E4
1	F=-0.0050+0.00471583*T-0.000360575*T^2+7.37702e-006*T^3	0.014	0.007	58.06	1	F=-6.7542+0.239277*T-0.00245866*T^2+8.41219e-006*T^3	0.003	0.001
2	F=-0.0042+0.00271281*T-0.000198846*T^2+5.06005e-006*T^3	0.005	0.005	58.82	2	F=-12.6278+0.458118*T-0.00511535*T^2+1.89683e-005*T^3	0.01	0.007
3	F=0.0008+0.000246047*T-6.49868e-005*T^2+5.53616e-006*T^3	0.002	0.003	48.83	3	F=-3.6576+0.150567*T-0.00162667*T^2+5.86891e-006*T^3	0.004	0.002
4	F=0.0000625-7.34043e-006*T+4.89312e-006*T^2+2.33062e-006*T^3	0.001	0.001	59.16	4	F=-3.9975+0.128007*T-0.00102523*T^2+2.4458e-006*T^3	0.006	0.007
5	F=0.0039-0.00200925*T+0.000139358*T^2+1.20179e-006*T^3	0.004	0.006	54.56	5	F=-4.2221+0.152055*T-0.00145496*T^2+4.56128e-006*T^3	0.016	0.005
6	F=-0.0010+0.00130032*T-0.000140139*T^2+5.35326e-006*T^3	0.002	0.003	53.92	6	F=-5.2358+0.196837*T-0.00207067*T^2+7.25815e-006*T^3	0.004	0.001
7	F=0.0039-0.00133847*T+0.000128384*T^2+2.50134e-006*T^3	0.006	0.009	47.72	7	F=-9.1003+0.448903*T-0.00751343*T^2+5.60183e-005*T^3-1.56731e-007*T^4	0.02	0.002
8	F=0.0012-0.000441683*T-2.48187e-005*T^2+8.21978e-006*T^3	0.001	0.001	40.86	8	F=-3.0391+0.148339*T-0.00180431*T^2+7.25267e-006*T^3	0.01	0.01
9	F=-0.0084+0.00511987*T-0.000318965*T^2+5.41153e-006*T^3	0.009	0.01	65.61	9	F=-17.3114+0.58308*T-0.00618559*T^2+2.18588e-005*T^3	0.009	0.003
10	F=0.0061-0.00322493*T+0.000236455*T^2+1.24001e-006*T^3	0.007	0.007	47.07	10	F=-1.5866+0.0655676*T-0.000505054*T^2+1.07459e-006*T^3	0.009	0.008
11	F=0.0016+0.00118221*T-0.000227667*T^2+8.68536e-006*T^3	0.007	0.009	48.42	11	F=-2.2633+0.0900979*T-0.000787698*T^2+2.12697e-006*T^3	0.009	0.01
12	F=0.0021+0.000426393*T-0.000106125*T^2+3.77989e-006*T^3	0.01	0.012	61.68	12	F=-3.8108+0.107707*T-0.000647107*T^2+5.03091e-007*T^3	0.015	0.015
13	F=0.0025-0.000998114*T+3.09787e-005*T^2+3.86258e-006*T^3	0.003	0.005	49.76	13	F=-4.0564+0.162172*T-0.00172815*T^2+6.11831e-006*T^3	0.011	0.004
14	F=0.0033-0.000987876*T+5.121e-006*T^2+4.40496e-006*T^3	0.004	0.009	49.76	14	F=-2.3246+0.0897293*T-0.000764677*T^2+1.99434e-006*T^3	0.009	0.011
15	F=-0.0024+0.00229898*T-0.000205294*T^2+6.12938e-006*T^3	0.004	0.006	54.45	15	F=-3.9021+0.141852*T-0.00135267*T^2+4.24129e-006*T^3	0.003	0.003
16	F=0.0054-0.00346582*T+0.000456133*T^2-3.40203e-006*T^3	0.005	0.008	47.21	16	F=-0.7585+0.0339852*T-0.000146832*T^2-1.71216e-007*T^3	0.002	0.003
17	F=0.0043-0.00201824*T+8.02397e-005*T^2+2.31425e-006*T^3	0.006	0.006	54.48	17	F=-1.8351+0.0583935*T-0.000271339*T^2-2.97664e-007*T^3	0.009	0.01
18	F=0.0043-0.00243019*T+0.000137944*T^2+2.96275e-006*T^3	0.006	0.007	47.15	18	F=-2.2168+0.0927334*T-0.000873016*T^2+2.6703e-006*T^3	0.005	0.006
19	F=0.0017-0.00149428*T+0.000164135*T^2+8.40208e-007*T^3	0.001	0.001	52.71	19	F=-1.6180+0.0540549*T-0.000250429*T^2-2.89242e-007*T^3	0.007	0.011
20	F=0.0027-0.00152504*T+0.000151867*T^2+1.27967e-006*T^3	0.002	0.002	51.54	20	F=-2.0405+0.0748308*T-0.000554835*T^2+1.10115e-006*T^3	0.007	0.006
21	F=0.0061-0.00409343*T+0.0005309*T^2+6.42679e-008*T^3	0.006	0.009	34.74	21	F=-1.1634+0.0725871*T-0.000820886*T^2+3.1165e-006*T^3	0.008	0.003
22	F=0.0009+0.00130111*T-0.000248203*T^2+1.09417e-005*T^3	0.002	0.007	43.94	22	F=-3.8187+0.17339*T-0.0020681*T^2+8.16344e-006*T^3	0.007	0.011
23	F=0.0035-0.000483909*T-8.07797e-005*T^2+5.15032e-006*T^3	0.011	0.014	52.92	23	F=-2.5592+0.0936264*T-0.000787004*T^2+2.06402e-006*T^3	0.002	0.002
24	F=0.0024-0.000945864*T+3.44704e-005*T^2+3.55354e-006*T^3	0.004	0.004	50.62	24	F=-4.4898+0.177821*T-0.00191706*T^2+6.87717e-006*T^3	0.008	0.002
25	F=0.0006+0.000230718*T-7.24356e-005*T^2+6.66216e-006*T^3	0.001	0.002	45.90	25	F=-3.3971+0.148547*T-0.00167455*T^2+6.2904e-006*T^3	0.005	0.005
26	F=0.0025-0.00110545*T+6.40375e-005*T^2+1.69192e-006*T^3	0.004	0.003	58.66	26	F=-4.8534+0.161355*T-0.00143855*T^2+4.0976e-006*T^3	0.012	0.007
27	F=0.0043-0.00227863*T+0.000139244*T^2+1.11462e-006*T^3	0.005	0.006	55.79	27	F=-2.7432+0.0886727*T-0.00059795*T^2+8.46792e-007*T^3	0.016	0.014
28	F=0.0049-0.00275874*T+0.000224553*T^2+2.27441e-006*T^3	0.005	0.006	43.82	28	F=-2.2986+0.104008*T-0.00108541*T^2+3.7494e-006*T^3	0.009	0.004
29	F=0.0032-0.000724754*T+9.54908e-006*T^2+2.22896e-006*T^3	0.005	0.01	61.27	29	F=-1.6822+0.0308066*T+0.000259106*T^2-2.99736e-006*T^3	0.014	0.015
30	F=0.0056-0.00189499*T+8.49e-005*T^2+2.31527e-006*T^3	0.007	0.011	53.82	30	F=-2.9705+0.105089*T-0.000878654*T^2+2.24414e-006*T^3	0.012	0.008
31	F=0.0034-0.00101799*T+7.09281e-007*T^2+4.76178e-006*T^3	0.005	0.009	48.82	31	F=-2.4661+0.098866*T-0.00091803*T^2+2.75549e-006*T^3	0.008	0.001
32	F=-0.0018+0.00219046*T-0.000206459*T^2+5.73641e-006*T^3	0.004	0.003	56.65	32	F=-9.3208+0.343378*T-0.00379682*T^2+1.39497e-005*T^3	0.015	0.005

E1 = Maximum Prediction Error When Computed Frequency < 5%

E2 = Maximum Prediction Error When Computed Frequency Between 5 - 50%

E3 = Maximum Prediction Error When Computed Frequency Between 50 - 95%

E4 = Maximum Prediction Error When Computed Frequency >95%

Table 23. Percent Probability of Predicted Temperatures >2.0C at Each Frequency Level by Group

Month: February

	STANDARDIZED FREQUENCY LEVELS																			% OF ALL >
GROUP	0.001	0.005	0.01	0.03	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	0.95	0.97	0.99	0.995	0.999	2.0C
1	33	33	17	17	17	17	17	17	17	17	17	17	0	0	0	0	0	0	0	12.3
2	0	0	0	0	0	50	50	50	50	50	50	50	50	50	50	50	0	0	0	28.9
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
6	8	0	0	0	0	0	8	8	8	8	8	0	0	0	0	0	0	8	0	2.8
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
9	25	25	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.9
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	10	10	1.6
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
12	0	25	25	25	25	25	25	25	0	0	0	0	0	0	0	0	0	0	0	9.2
13	0	5	5	5	5	5	5	5	5	5	5	5	0	0	0	5	0	0	0	3.3
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
15	20	20	20	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5.3
16	0	0	0	0	0	0	0	0	0	33	33	66	66	0	0	0	0	0	0	10.5
17	8	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.9
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
19	0	25	25	25	25	25	0	0	0	25	0	0	0	0	0	0	0	0	0	7.9
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
21	0	0	0	0	0	0	0	0	0	0	0	25	25	25	25	25	0	0	0	6.6
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
24	16	8	16	8	0	0	0	8	8	8	8	16	16	0	0	0	8	0	0	6.6
25	8	0	0	0	0	0	0	0	0	0	0	0	0	8	8	8	8	8	0	2.4
26	14	14	14	28	14	14	14	14	0	0	0	0	0	0	0	0	0	0	0	6.8
27	0	0	0	33	33	33	33	0	0	0	0	0	0	0	0	0	0	0	0	7.0
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
30	0	20	40	40	20	20	20	0	0	0	0	0	0	0	20	20	20	20	20	15.8
31	0	0	0	0	0	0	0	0	0	0	0	9	9	9	9	9	0	0	0	2.4
32	0	33	0	0	0	0	0	0	33	33	33	33	0	0	0	0	0	0	0	1.8

Skewness in the Pacific islands shows weak positive skew (+0.002) in Group 11 and a much stronger positive skew in Group 22 (+0.272), which is perhaps indicative of the slight restrengthening of the Pacific high and the northward migration of the western storm tracks. Group 14 has a weak negative (-0.05) skew.

February group means for the attribute variables appear in Table 19, group mean normalized temperatures in Table 20, discriminant functions in Table 21, curve-fitting equations in Table 22, and percent probabilities by frequency level in Table 23.

Spring: March, April, May

The spring months witness a struggle between storm and sun control. Many times throughout the season there appears to be something of an oscillation between summer and winter conditions (Trewartha, 1954). As a whole, the model performed slightly better during spring than during the winter season. About 67 percent of the stations (combine model building and validation data sets) had no errors at any frequency level during the spring season. Overall, about 91 percent of all generated levels were within tolerance.

March -- Although March had the most groups (36) of any month , it had, by far, the greatest number of levels out of tolerance of any month. Only 84 percent of all generated levels were within tolerance, and roughly 55 percent of the stations in the combined model building and validation data sets had no errors.

A number of authors have discussed the overall variability of the month of March. Ludlum (1982) notes that the month itself is named after the Roman god of war and that during this transition month a constant battle occurs between cold, dry Polar air and warm, moist, tropical air from the Gulf of Mexico. Kimble (1968) notes that during March the northerly latitudes are still fairly close to their winter temperature minimums while more southerly locations are experiencing summer-like warm. Thus, a large north-to-south temperature gradient exists, promoting the movement of air, active fronts and attendant storm centers.

Figure 40 shows the March temperature frequency group patterns for North America and Figure 41 shows the same for the islands in the Pacific Ocean. March is comprised of 36 groups.

Hare and Hay (1974) point out that although March is conventionally thought of as a spring month, its temperature patterns are similar to that of winter. This is confirmed when the March group patterns in Figure 36 are compared to the previous patterns for the winter months. They are fairly identical over most of North America. The latitudinal

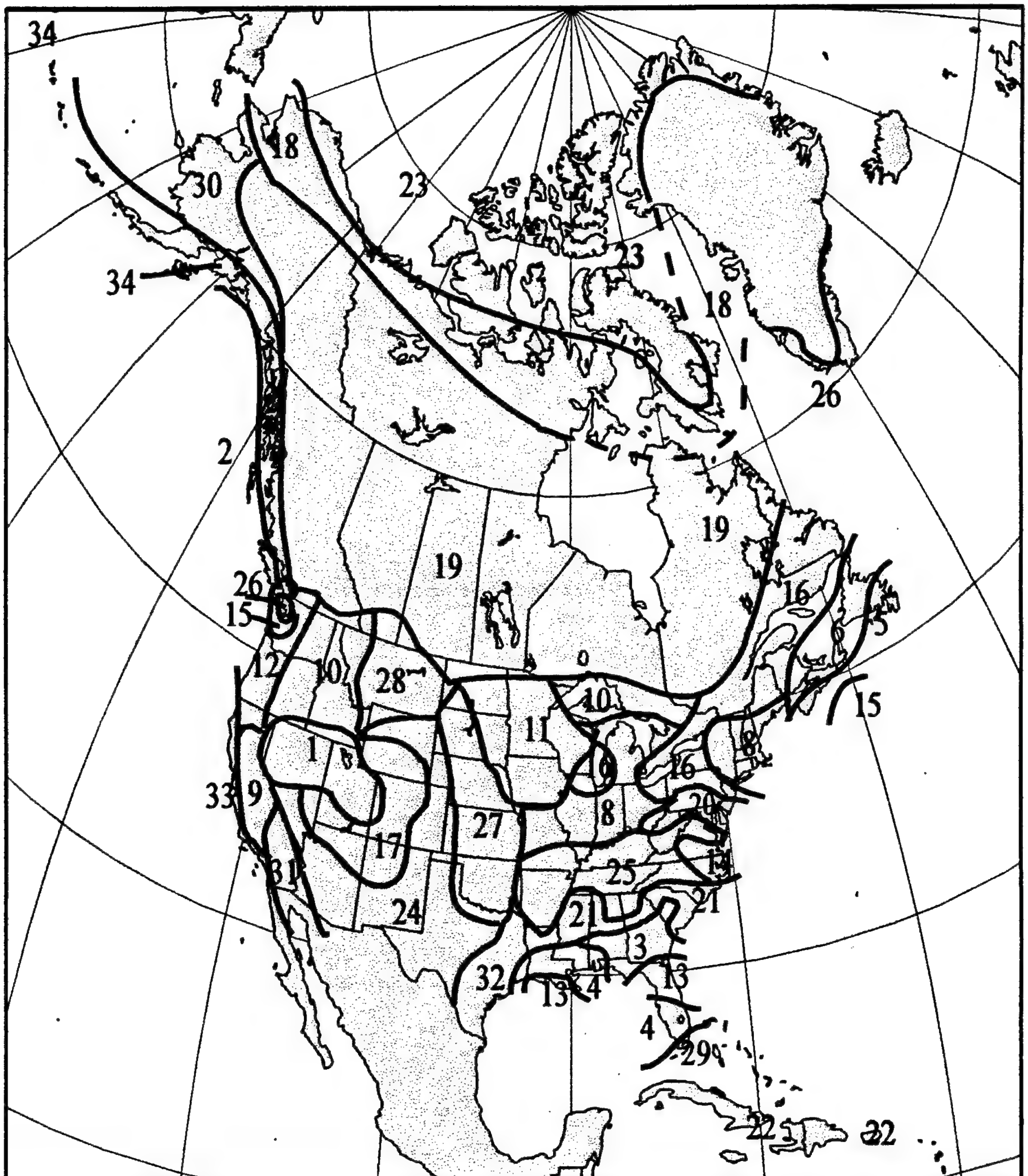

FIGURE 40. NORTH AMERICA TEMPERATURE FREQUENCY GROUPS
FOR MARCH

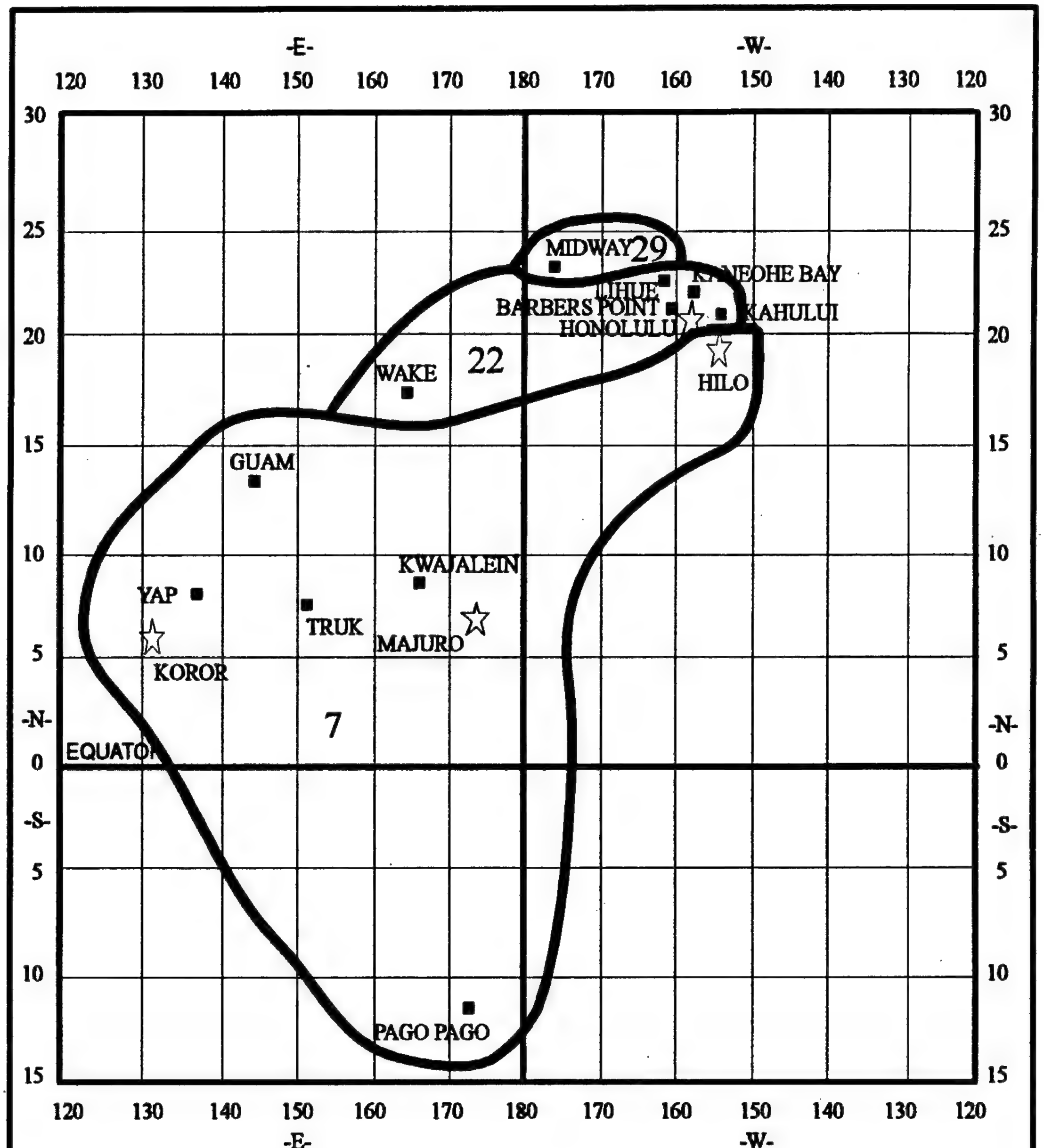

FIGURE 41. PACIFIC ISLANDS TEMPERATURE FREQUENCY GROUPS FOR MARCH

trend is persisting in the southeast U.S. Groups 24 & 27 outline the Cfa/Dfa and Bsk boundary. The west coast of the U.S. is again partitioned into a group comprising coastal California, and further North along the coast, groups that highlight the Marine West Coast climate type of the Pacific Northwest.

The pattern in the High Arctic as well as for most of Canada is quite similar to February's patterns. The patterns in the Pacific islands (Figure 37) is practically identical to February's Pacific patterns (Figure 33).

Figures 42 and 43 show the group mean March skewness for North America and the Pacific islands, respectively. Skewness still remains highly positive in the High Arctic and along the southern California coast. More and more groups are becoming positive, especially to the east of California and along the Atlantic seaboard. This could be the result of the intensification of the Eastern Pacific high and the Bermuda high -- i.e. milder air being advected into these regions from more southerly latitudes. High negative groups are still found in southern portions of Florida.

In the Pacific, Midway (Group 29) shows a fairly high negative skewness. It is the northernmost of the Pacific islands in the data set, hence, still may be affected by more cyclonic activity than the more southerly locations. It also is grouped with the Key West stations, both of which have high negative skewness (-0.56). The actual skewness for Midway is only slightly negative (-0.05).

March group means for the attribute variables appear in Table 24, group mean normalized temperatures in Table 25, discriminant functions in Table 26, curve-fitting equations in Table 27, and percent probabilities by frequency level in Table 28.

<u>April</u> -- Unlike March, which possessed the highest number of errors of any month, model accuracy begins improving in April. Accuracy increases to 64 percent of all stations (model building and validation data sets) having no errors and about 92 percent of all generated levels within the +/-2.0°C tolerance. April is comprised of 26 groups. Although this is 10 groups less than the number required for March, the overall spatial patterns between the two months are quite similar.

Figure 44 shows the April temperature frequency group patterns for North America, and Figure 45 shows the same for the islands in the Pacific Ocean. The Group 10 and 22 boundary is quite close to the Cfa/Dfa boundary. The western boundaries of Groups 10 and 22 correspond quite closely to the "Humid-Subhumid" P/E boundary (Figure 10). The southern boundary of Group 7 coincides nearly with the southern boundary of the 50-59 continentality region (Figure 12). Group 24 represents a good portion of the Bsk (steppe) climate. Group 6 encompasses coastal California and, northward along the coast, Groups 26, 21 and 2 represent the Marine West Coast climate

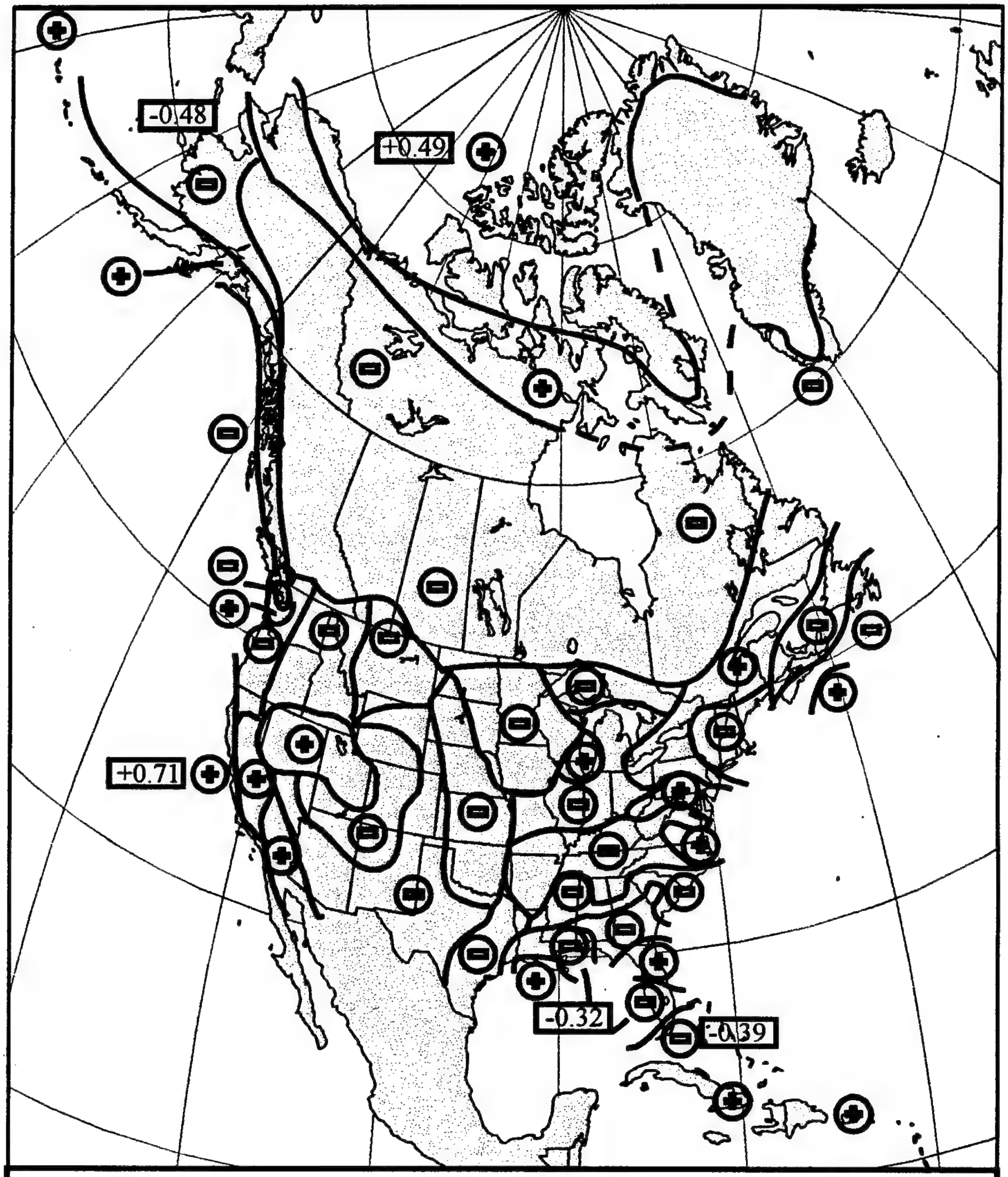

FIGURE 42. NORTH AMERICA TEMPERATURE FREQUENCY GROUP SKEWNESS FOR MARCH

⊕ = POSITIVE SKEW ⊖ = NEGATIVE SKEW

▭ = values >/= 0.3 or </= -0.3

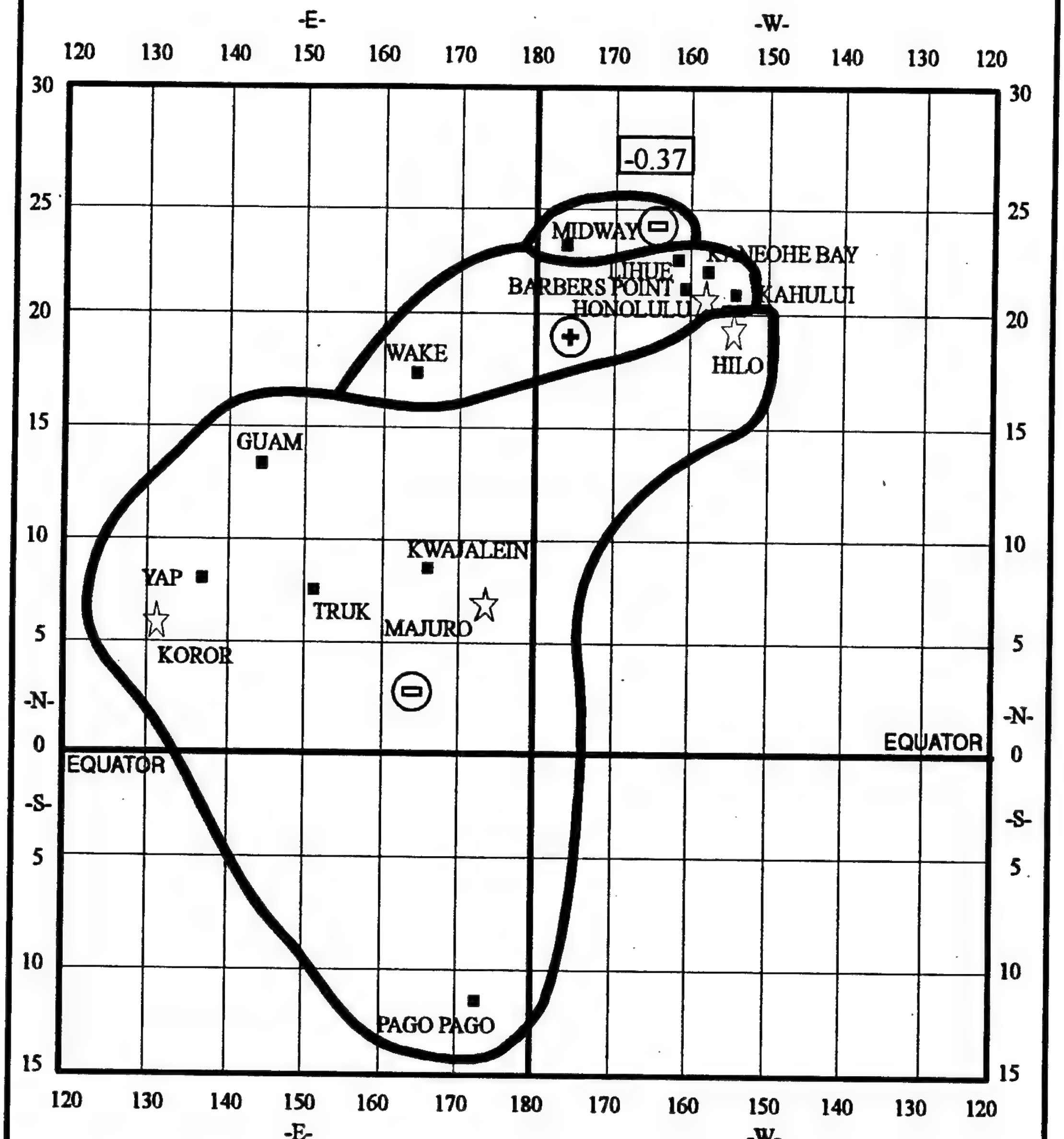

FIGURE 43. PACIFIC ISLANDS TEMPERATURE FREQUENCY GROUP SKEWNESS FOR MARCH

(+) = POSITIVE SKEW (−) = NEGATIVE SKEW

[ ] = VALUES >/= 0.3 OR </= -0.3

Table 24. Group Means for March

Group	Station Count	Latitude	Elevation	P/E	Continentality	Temperature Range Monthly	Temperature Range Daily	Normalized Mean Daily Max Temp	Normalized Mean Daily Min Temp
1	6	40.66	4472	23.7	43.2	81.7	24.2	72.3	48.8
2	2	53.74	104	338.0	11.8	65.5	16.0	68.3	47.4
3	2	31.66	2380	22.7	40.7	87.5	28.5	70.9	41.9
4	8	29.66	74	87.8	27.5	65.8	19.5	72.9	44.3
5	4	46.27	306	171.4	34.9	72.3	14.3	64.0	42.7
6	1	47.62	459	197.3	27.4	68.0	12.0	55.7	38.5
7	5	10.70	62	147.9	-9.9	22.0	10.4	75.6	29.7
8	12	40.48	625	95.6	45.7	95.6	19.1	64.3	44.0
9	3	38.04	677	22.9	31.5	64.7	24.3	65.4	31.2
10	4	47.33	2309	58.5	37.1	87.3	19.0	73.5	54.1
11	11	43.66	1045	62.4	53.6	110.4	19.5	61.9	41.3
12	2	45.75	630	63.9	25.4	72.0	22.0	74.3	51.9
13	1	38.52	18	35.4	25.1	62.0	21.0	69.8	33.9
14	5	36.33	319	82.7	35.9	75.8	20.4	59.4	33.6
15	3	43.88	74	161.3	26.3	51.0	11.0	64.7	43.8
16	17	43.16	614	96.1	44.4	87.3	16.9	59.5	40.9
17	5	39.52	5638	27.5	41.7	87.4	25.4	68.8	42.2
18	2	66.79	732	52.5	37.9	89.0	16.0	55.5	38.9
19	4	56.47	866	39.9	54.9	98.8	22.8	63.1	42.3
20	12	39.96	280	96.7	41.3	83.8	18.5	57.1	37.2
21	6	33.63	344	92.4	35.5	76.8	22.5	65.2	35.2
22	6	20.81	45	36.3	-1.4	32.5	13.0	73.4	33.0
23	4	73.30	36	26.8	40.8	79.8	11.8	45.2	32.3
24	7	37.65	3715	23.1	42.2	92.9	28.0	69.0	39.4
25	8	35.28	935	88.4	37.1	80.0	22.6	65.6	40.0
26	4	55.47	94	75.1	10.5	58.3	10.5	63.0	46.9
27	7	38.90	1648	49.5	50.6	101.9	23.9	61.8	39.0
28	6	48.45	3280	33.7	41.6	99.2	20.2	67.2	47.1
29	3	26.18	15	58.4	9.5	43.3	11.0	73.0	45.4
30	2	59.73	87	55.5	30.8	93.0	17.0	64.2	47.6
31	5	33.99	1669	7.2	40.3	72.2	28.0	66.8	29.5
32	6	29.47	230	41.7	35.3	79.8	20.8	62.3	36.0
33	9	34.79	51	21.3	5.8	55.8	15.0	58.8	28.7
34	3	53.64	62	157.0	10.8	55.7	12.0	63.0	44.7
35	6	32.96	209	85.5	33.8	75.7	24.8	69.3	37.4
36	7	29.27	28	73.3	24.7	64.6	21.0	70.0	37.0
ALL	198	39.32	985	72.6	34.1	78.3	19.4	64.8	39.7

Table 25. Group Mean Normalized Temperatures: March

	Frequency Levels																				
Group	0	0.001	0.005	0.01	0.03	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	0.95	0.97	0.99	0.995	0.999	1.0
1	0	11.04	17.66	20.82	26.22	29.16	33.73	38.96	42.74	46.13	49.54	53.08	57.02	61.86	68.82	74.39	77.98	84.08	87.14	91.91	100
2	0	7.76	17.72	21.77	28.09	31.80	37.77	44.75	49.21	52.57	55.30	57.62	60.01	62.71	66.59	70.27	73.09	79.14	82.20	88.22	100
3	0	9.59	16.07	19.23	25.06	27.83	32.64	39.67	44.58	48.92	53.10	57.05	61.41	66.68	73.56	78.78	81.58	86.27	88.46	93.37	100
4	0	8.44	16.10	19.52	26.17	29.97	36.26	44.47	50.32	55.06	59.29	62.97	66.63	70.60	75.88	79.80	82.08	85.93	87.68	91.54	100
5	0	6.38	12.22	15.93	23.51	26.95	32.47	40.23	45.69	49.65	52.47	54.95	57.84	61.18	66.39	71.21	74.16	78.62	81.89	87.68	100
6	0	6.89	16.39	20.82	27.57	31.16	36.74	43.89	48.48	52.30	54.53	56.75	59.76	63.20	69.41	76.50	80.14	87.56	90.57	95.42	100
7	0	9.18	15.75	19.02	24.57	28.12	32.30	37.84	41.96	45.68	49.39	53.64	58.84	64.46	70.69	74.67	76.78	81.35	83.57	88.12	100
8	0	9.39	18.08	22.00	28.22	31.28	35.65	40.71	44.31	47.45	50.54	53.82	57.55	62.21	68.86	73.96	77.29	83.32	86.25	91.48	100
9	0	6.18	11.34	13.85	18.10	20.70	24.75	30.42	34.58	38.55	42.38	46.35	50.66	56.22	64.26	70.74	74.85	81.49	85.12	92.01	100
10	0	12.74	20.22	24.31	31.88	35.85	41.44	47.02	50.72	53.74	56.51	59.22	62.11	65.32	69.88	74.07	77.06	82.69	85.58	91.25	100
11	0	12.43	19.66	23.05	28.74	31.86	36.89	42.53	46.34	49.27	51.69	53.99	56.55	60.12	66.06	71.53	75.11	81.82	85.33	92.10	100
12	0	15.23	21.73	24.59	29.06	31.34	35.27	40.64	44.68	48.24	51.56	54.79	58.11	62.00	67.54	72.15	75.06	81.79	84.94	90.36	100
13	0	8.12	13.27	15.13	19.58	21.66	25.44	30.31	34.11	37.68	41.23	44.85	48.90	54.09	61.34	67.88	71.98	78.53	81.83	86.98	100
14	0	4.36	11.55	14.37	19.25	21.88	26.39	32.37	36.72	40.61	44.49	48.74	53.56	59.28	67.03	73.09	77.02	84.11	87.20	92.87	100
15	0	6.18	12.18	15.14	20.86	24.82	30.81	37.52	41.95	45.25	48.09	50.72	53.78	57.59	63.77	68.68	71.59	76.94	79.66	85.49	100
16	0	6.11	12.64	15.97	21.83	25.07	29.71	35.54	39.58	42.74	45.63	48.69	52.20	56.82	64.13	70.09	74.11	81.66	85.30	91.92	100
17	0	7.25	12.81	16.23	23.29	27.13	32.68	38.83	42.98	46.53	50.06	53.89	58.33	63.71	71.11	76.68	79.79	85.34	87.92	92.81	100
18	0	2.99	8.21	11.52	17.57	20.35	24.21	31.09	36.21	40.32	44.93	48.59	53.44	59.58	70.15	76.60	80.72	88.81	91.69	94.56	100
19	0	6.16	13.18	16.10	23.02	27.41	34.64	42.80	48.20	52.84	56.89	60.67	64.35	68.34	73.47	77.45	80.31	85.05	87.87	92.62	100
20	0	7.78	14.26	17.63	22.99	25.84	30.14	35.14	38.67	41.79	44.88	48.25	52.15	57.04	64.36	70.45	74.62	82.41	86.35	92.97	100
21	0	8.97	16.41	19.26	24.59	27.46	32.55	39.68	45.03	49.75	54.04	58.13	62.18	66.84	73.00	78.19	81.24	86.50	89.15	93.87	100
22	0	6.22	11.93	14.69	20.88	24.30	29.35	35.55	39.43	43.21	46.97	51.07	55.58	60.65	67.12	71.60	74.28	78.88	81.82	86.77	100
23	0	4.60	8.12	9.87	13.47	15.66	19.29	24.15	28.23	31.77	35.30	39.20	42.85	48.85	57.79	65.90	71.70	80.97	87.38	94.25	100
24	0	8.74	16.27	19.42	25.21	28.42	33.39	39.28	43.44	47.01	50.62	54.46	58.78	63.97	71.32	76.96	80.02	85.20	87.69	92.25	100
25	0	8.20	15.27	18.35	23.60	26.37	30.92	37.13	42.09	46.49	50.86	55.17	59.70	64.76	71.49	76.93	80.14	85.61	88.24	92.68	100
26	0	8.78	15.51	19.80	26.02	29.19	34.33	40.70	44.98	48.86	52.55	56.08	59.38	63.53	68.99	73.20	75.81	81.20	84.20	90.97	100
27	0	9.23	16.53	20.46	26.54	29.89	34.55	39.69	43.46	46.85	50.10	53.62	57.72	62.86	70.05	75.69	79.24	85.17	88.14	93.30	100
28	0	5.30	12.20	16.48	24.85	30.15	37.33	45.59	50.65	54.22	57.19	59.97	63.20	67.19	72.80	77.53	80.55	85.84	88.86	93.93	100
29	0	11.15	19.92	23.39	29.88	33.66	39.71	47.41	52.49	56.35	59.73	62.64	65.70	69.22	74.15	77.96	80.09	84.09	85.87	90.05	100
30	0	11.47	19.80	23.00	29.68	33.89	40.44	48.90	55.35	60.91	66.11	71.00	75.24	79.19	82.95	85.19	86.80	89.70	90.94	94.69	100
31	0	7.93	13.35	16.05	20.99	23.66	27.88	33.52	38.03	42.19	42.57	51.08	56.06	61.73	69.36	74.74	78.02	83.68	86.34	90.65	100
32	0	9.31	14.78	17.79	23.43	26.74	32.16	39.16	44.44	48.92	52.68	56.08	59.21	62.82	68.05	72.30	74.87	79.41	82.16	88.79	100
33	0	5.13	9.35	11.69	15.76	17.88	21.45	25.77	28.75	31.35	33.80	36.38	39.20	42.74	48.07	53.46	57.57	65.95	70.83	81.53	100
34	0	6.01	11.46	13.94	20.29	23.50	29.46	36.42	40.78	44.69	47.96	50.73	53.54	57.05	62.12	66.67	69.55	75.25	78.39	87.53	100
35	0	9.70	15.97	18.77	24.00	27.16	32.83	40.52	46.26	51.16	55.76	59.96	64.32	69.20	75.84	80.91	83.81	88.63	90.74	94.50	100
36	0	7.88	15.18	18.33	24.98	28.86	35.11	43.28	49.05	53.80	58.04	62.01	66.15	70.86	77.12	81.70	84.36	88.53	90.31	93.59	100

Table 26. Discriminant Function Values: March

Function value = (a x lat) + (b x elev) + (c x P/E) + (d x K) + (e x mrange) + (f x drange) + (g x nmax) + (h x nmin) + constant

Group	a	b	c	d	e	f	g	h	constant
1	8.410	0.022	-0.283	4.067	-0.324	-0.132	14.701	-1.046	-799.239
2	8.479	0.007	0.902	1.350	-0.305	3.308	11.541	-0.156	-798.74
3	6.980	0.008	-0.256	3.630	0.231	1.155	13.662	-1.249	-678.934
4	6.721	-0.002	-0.143	2.908	0.201	-1.017	14.426	-1.715	-621.217
5	7.986	0.004	0.161	3.218	0.049	-1.071	13.793	-2.028	-651.034
6	7.621	0.006	0.329	2.488	0.019	-0.275	11.842	-1.647	-550.016
7	5.486	0.006	0.051	0.811	0.339	-6.938	17.898	-7.347	-568.181
8	7.004	0.000	-0.095	3.770	0.599	-0.547	13.197	-1.176	-648.415
9	8.217	0.002	-0.352	3.188	-0.035	-0.878	15.290	-3.927	-633.744
10	8.752	0.010	-0.285	3.542	0.034	-1.069	14.995	-0.615	-805.022
11	7.182	0.001	-0.240	4.212	0.953	-1.836	13.970	-2.236	-682.351
12	8.765	0.000	-0.247	2.717	-0.225	1.132	13.981	0.153	-758.375
13	8.470	-0.001	-0.396	2.884	0.114	-2.696	16.810	-4.716	-677.837
14	6.871	0.000	-0.086	3.153	0.330	-0.237	12.882	-2.444	-533.277
15	8.099	0.004	0.093	2.867	-0.356	-1.754	13.975	-1.885	-618.313
16	7.276	0.001	-0.091	3.691	0.386	-0.845	12.841	-1.476	-597.899
17	8.208	0.029	-0.199	3.853	-0.129	-0.559	14.807	-2.425	-771.797
18	10.525	0.003	-0.350	3.293	0.067	-1.465	14.474	-2.637	-750.879
19	9.234	0.001	-0.342	4.532	0.269	-0.324	14.698	-1.939	-812.151
20	6.823	-0.001	-0.038	3.398	0.417	0.177	12.005	-1.426	-544.846
21	6.835	0.000	-0.056	3.212	0.366	-0.195	13.749	-2.718	-585.069
22	6.852	0.002	-0.428	1.396	0.221	-6.434	17.961	-6.222	-584.744
23	11.150	0.000	-0.489	3.496	-0.123	-2.541	14.190	-3.426	-722.773
24	7.799	0.017	-0.244	3.741	0.208	0.206	14.564	-2.455	-724.125
25	6.893	0.003	-0.052	3.290	0.251	0.619	12.973	-1.410	-599.587
26	9.587	0.001	-0.296	1.687	-0.230	-2.085	14.179	-1.362	-664.494
27	6.949	0.004	-0.194	4.047	0.621	0.182	12.971	-1.602	-643.176
28	8.649	0.015	-0.327	3.685	0.326	-1.645	14.909	-1.835	-765.704
29	6.748	0.000	-0.349	1.989	0.093	-4.544	15.784	-2.784	-581.426
30	9.671	-0.003	-0.362	2.806	0.328	-0.920	14.323	-1.144	-765.452
31	7.863	0.007	-0.360	3.804	0.039	-0.666	15.604	-4.345	-667.289
32	6.105	-0.003	-0.259	3.147	0.602	-0.903	13.097	-2.147	-527.253
33	7.355	-0.001	-0.400	1.304	0.433	-3.644	14.711	-4.660	-481.031
34	9.128	0.003	0.090	1.601	-0.332	-0.453	13.230	-1.260	-640.91
35	7.006	-0.001	-0.085	3.152	0.277	0.513	13.990	-2.319	-626.393
36	6.814	-0.002	-0.178	2.685	0.298	-1.383	14.841	-3.130	-586.418

INPUT VARIABLES
lat = latitude
elev = elevation
P/E = Precipitation Effectiveness Index
K = Continentality
mrange = monthly temperature range
drange = daily temperature range
nmax = normalized mean daily maximum temperature
nmin = normalized mean daily minimum temperature

Table 27. Temperature Frequency Equations: March

Group	If Input Normalized Temperature (T) < 50th Percentile Normalized Temperature (T)	Maximum Error E1	Maximum Error E2	50th Percentile Normalized T	Group	If Input Normalized Temperature (T) > 50th Percentile Normalized Temperature (T)	Maximum Error E3	Maximum Error E4
1	F=0.0014+0.00113352*T-0.000204557*T^2+7.85968e-006*T^3	0.005	0.008	49.54	1	F=-3.3976+0.137013*T-0.00142253*T^2+4.92091e-006*T^3	0.003	0.001
2	F=-0.0045+0.0034233*T-0.000275841*T^2+6.80626e-006*T^3	0.007	0.007	55.30	2	F=-10.7935+0.412684*T-0.00478967*T^2+1.84242e-005*T^3	0.011	0.012
3	F=0.0037-0.00161186*T+3.44652e-005*T^2+3.29366e-006*T^3	0.006	0.008	53.10	3	F=-2.7794+0.101327*T-0.000871576*T^2+2.35954e-006*T^3	0.003	0.004
4	F=0.0015-0.000386849*T-1.23766e-005*T^2+2.72497e-006*T^3	0.002	0.002	59.29	4	F=-4.7787+0.15561*T-0.00133972*T^2+3.61056e-006*T^3	0.009	0.010
5	F=-0.0019+0.00134238*T-0.000119423*T^2+5.20589e-006*T^3	0.002	0.008	52.47	5	F=-6.9655+0.273677*T-0.003126*T^2+1.18593e-005*T^3	0.006	0.006
6	F=-0.0041+0.00308083*T-0.000254229*T^2+6.64773e-006*T^3	0.006	0.005	54.53	6	F=-7.4294+0.28553*T-0.00323174*T^2+1.22019e-005*T^3	0.012	0.008
7	F=0.0031-0.000412501*T-8.33138e-005*T^2+6.08021e-006*T^3	0.005	0.007	49.39	7	F=-1.6916+0.0640139*T-0.000427059*T^2+5.56256e-007*T^3	0.011	0.014
8	F=-0.0010+0.00307499*T-0.000333946*T^2+9.34754e-006*T^3	0.005	0.008	50.54	8	F=-3.9510+0.156814*T-0.00165514*T^2+5.82052e-006*T^3	0.001	0.001
9	F=0.0059-0.00381709*T+0.000246551*T^2+2.91693e-006*T^3	0.008	0.009	42.38	9	F=-1.9692+0.0940671*T-0.000994676*T^2+3.50925e-006*T^3	0.003	0.001
10	F=-0.0040+0.00524654*T-0.000406016*T^2+8.31537e-006*T^3	0.013	0.009	56.51	10	F=-8.8148+0.326201*T-0.00360791*T^2+1.32741e-005*T^3	0.008	0.004
11	F=-0.0027+0.00464186*T-0.000409975*T^2+9.78449e-006*T^3	0.009	0.005	51.69	11	F=-6.5821+0.263164*T-0.00304011*T^2+1.16731e-005*T^3	0.012	0.011
12	F=0.0018+0.000765499*T-0.000191451*T^2+7.13299e-006*T^3	0.007	0.009	51.56	12	F=-5.2433+0.205499*T-0.00225111*T^2+8.20376e-006*T^3	0.007	0.004
13	F=0.0053-0.00355765*T+0.000164347*T^2+5.33688e-006*T^3	0.010	0.013	41.23	13	F=-2.1500+0.1051*T-0.0011696*T^2+4.33662e-006*T^3	0.003	0.002
14	F=0.0052-0.0028901*T+0.000159471*T^2+3.59203e-006*T^3	0.006	0.008	44.49	14	F=-1.8696+0.0845229*T-0.000821849*T^2+2.63345e-006*T^3	0.004	0.002
15	F=-0.0032+0.00234338*T-0.000210363*T^2+7.85486e-006*T^3	0.004	0.004	48.09	15	F=-4.8106+0.202248*T-0.00233978*T^2+8.98493e-006*T^3	0.007	0.005
16	F=-0.0007+0.00155485*T-0.000206771*T^2+9.07737e-006*T^3	0.002	0.003	45.63	16	F=-3.2967+0.145305*T-0.00164125*T^2+6.18195e-006*T^3	0.005	0.005
17	F=0.0000504+0.00116082*T-0.00015268*T^2+6.63071e-006*T^3	0.002	0.008	50.06	17	F=-2.6579+0.104924*T-0.000989903*T^2+3.06269e-006*T^3	0.001	0.002
18	F=0.0068-0.00382297*T+0.000300659*T^2+7.28643e-007*T^3	0.008	0.011	44.93	18	F=-1.9567+0.0896496*T-0.00091847*T^2+3.17993e-006*T^3	0.005	0.003
19	F=-0.0002+0.00041112*T-4.08382e-005*T^2+3.32052e-006*T^3	0.001	0.003	56.89	19	F=-4.9532+0.171722*T-0.00162131*T^2+4.98859e-006*T^3	0.013	0.007
20	F=0.0011+0.00117007*T-0.000225104*T^2+1.00599e-005*T^3	0.003	0.009	44.88	20	F=-2.8394+0.126955*T-0.00140313*T^2+5.1769e-006*T^3	0.002	0.003
21	F=0.0043-0.00221002*T+8.33074e-005*T^2+2.39837e-006*T^3	0.008	0.007	54.04	21	F=-3.4138+0.122974*T-0.00111414*T^2+3.25333e-006*T^3	0.008	0.004
22	F=0.0026-0.000562673*T-2.92146e-005*T^2+5.77467e-006*T^3	0.006	0.010	46.97	22	F=-2.3737+0.0988259*T-0.000941328*T^2+2.90113e-006*T^3	0.008	0.010
23	F=0.0060-0.00518812*T+0.000532125*T^2+4.72227e-007*T^3	0.007	0.007	35.30	23	F=-1.3680+0.0822132*T-0.00095925*T^2+3.74446e-006*T^3	0.012	0.005
24	F=0.0015+0.000471975*T-0.000130903*T^2+6.31612e-006*T^3	0.004	0.009	50.62	24	F=-2.8280+0.110363*T-0.00104799*T^2+3.27009e-006*T^3	0.002	0.002
25	F=0.0060-0.00297417*T+0.000121996*T^2+2.5861e-006*T^3	0.009	0.011	50.86	25	F=-2.5208+0.096197*T-0.000846594*T^2+2.36298e-006*T^3	0.007	0.004
26	F=0.0016+0.000363091*T-0.000110493*T^2+5.46249e-006*T^3	0.003	0.008	52.55	26	F=-4.9979+0.190746*T-0.00201358*T^2+7.05643e-006*T^3	0.011	0.005
27	F=0.0002+0.00194517*T-0.000251491*T^2+8.29248e-006*T^3	0.004	0.009	50.10	27	F=-3.2204+0.128374*T-0.00130011*T^2+4.38353e-006*T^3	0.001	0.001
28	F=-0.0062+0.00338249*T-0.000226102*T^2+5.57848e-006*T^3	0.006	0.009	57.19	28	F=-7.0131+0.253719*T-0.00267932*T^2+9.43444e-006*T^3	0.002	0.001
29	F=-0.0016+0.00184375*T-0.000166395*T^2+4.61187e-006*T^3	0.003	0.003	59.73	29	F=-8.3208+0.288811*T-0.00297133*T^2+1.01511e-005*T^3	0.007	0.005
30	F=0.0035-0.0013318*T+3.22699e-005*T^2+1.55977e-006*T^3	0.006	0.007	66.11	30	F=70.2668-3.42823*T+0.0618463*T^2-0.000485512*T^3+1.40603e-006*T^4	0.013	0.005
31	F=-0.0006+0.00181464*T-0.000262769*T^2+1.16729e-005*T^3	0.009	0.004	42.57	31	F=4.2039-0.259745*T+0.00624776*T^2-6.01994e-005*T^3+2.04939e-007*T^4	0.009	0.004
32	F=0.0022-0.000983505*T+1.65856e-005*T^2+3.46573e-006*T^3	0.003	0.004	52.68	32	F=-5.7516+0.220671*T-0.00239573*T^2+8.64002e-006*T^3	0.012	0.003
33	F=0.0017-0.000140754*T-0.000145519*T^2+1.75101e-005*T^3	0.002	0.006	33.80	33	F=-4.0522+0.261711*T-0.00507274*T^2+4.34671e-005*T^3-1.38587e-007*T^4	0.005	0.005
34	F=-0.0004+0.000644903*T-7.8667e-005*T^2+5.91028e-006*T^3	0.009	0.004	47.96	34	F=-5.3441+0.225016*T-0.00264599*T^2+1.03047e-005*T^3	0.006	0.009
35	F=0.0035-0.0020759*T+9.46482e-005*T^2+1.86703e-006*T^3	0.007	0.005	55.76	35	F=-2.7900+0.0942114*T-0.000721231*T^2+1.57711e-006*T^3	0.006	0.004
36	F=0.0016-0.000495224*T-3.73656e-007*T^2+2.71935e-006*T^3	0.002	0.002	58.04	36	F=-3.1508+0.100864*T-0.000740883*T^2+1.46952e-006*T^3	0.007	0.005

E1 = Maximum Prediction Error When Computed Frequency < 5%
E2 = Maximum Prediction Error When Computed Frequency Between 5 - 50%
E3 = Maximum Prediction Error When Computed Frequency Between 50 - 95%
E4 = Maximum Prediction Error When Computed Frequency >95%

Table 28. Percent Probability of Predicted Temperatures >2.0C at Each Frequency Level by Group

Month: March

	STANDARDIZED FREQUENCY LEVELS																			% OF ALL >
GROUP	0.001	0.005	0.01	0.03	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	0.95	0.97	0.99	0.995	0.999	2.0C
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
2	0	50	50	50	50	50	50	50	50	50	50	50	50	50	0	0	0	0	0	34.2
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
4	12	0	0	0	12	12	12	12	0	0	0	0	0	0	0	0	0	0	0	3.3
5	0	0	0	0	0	0	0	0	25	25	25	25	25	25	25	25	25	25	25	14.5
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
8	0	8	8	0	0	0	0	0	0	8	17	17	25	33	33	33	25	17	8	9.6
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
10	0	0	0	0	0	0	0	0	0	25	25	25	25	0	0	0	0	0	0	5.3
11	27	18	27	18	18	18	9	9	9	9	9	9	9	0	0	0	9	9	9	11.0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
14	0	0	0	0	0	0	0	0	0	20	20	0	0	0	0	0	0	0	0	2.1
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
16	0	6	6	6	6	6	0	0	0	0	0	0	6	12	6	6	12	0	0	3.7
17	20	20	20	20	20	20	20	20	0	0	0	0	0	0	0	0	0	0	0	8.4
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
19	0	0	0	0	25	0	0	0	0	0	25	25	25	25	0	0	0	0	0	6.6
20	0	0	0	0	0	0	0	0	0	0	0	8	17	17	17	25	25	17	8	7.0
21	17	17	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.6
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
23	0	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	0	0	21.0
24	0	14	29	29	14	14	14	0	0	0	0	0	0	0	0	0	0	0	0	6.0
25	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	0	0	0	9.4
26	25	25	0	0	0	0	0	25	25	25	0	0	0	25	25	25	25	25	25	14.5
27	14	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.3
28	0	0	0	0	0	0	0	0	17	17	17	0	0	0	0	0	0	0	0	2.6
29	0	0	0	0	0	0	33	33	33	33	33	0	0	0	0	0	0	0	0	8.8
30	0	0	0	0	0	0	0	50	50	50	0	0	0	0	0	0	0	0	0	7.9
31	0	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	1.1
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
33	0	0	0	0	0	0	0	0	0	0	0	0	11	11	22	22	22	22	22	7.0
34	0	0	0	0	33	33	0	33	33	0	0	0	0	0	0	0	0	0	0	7.0
35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0

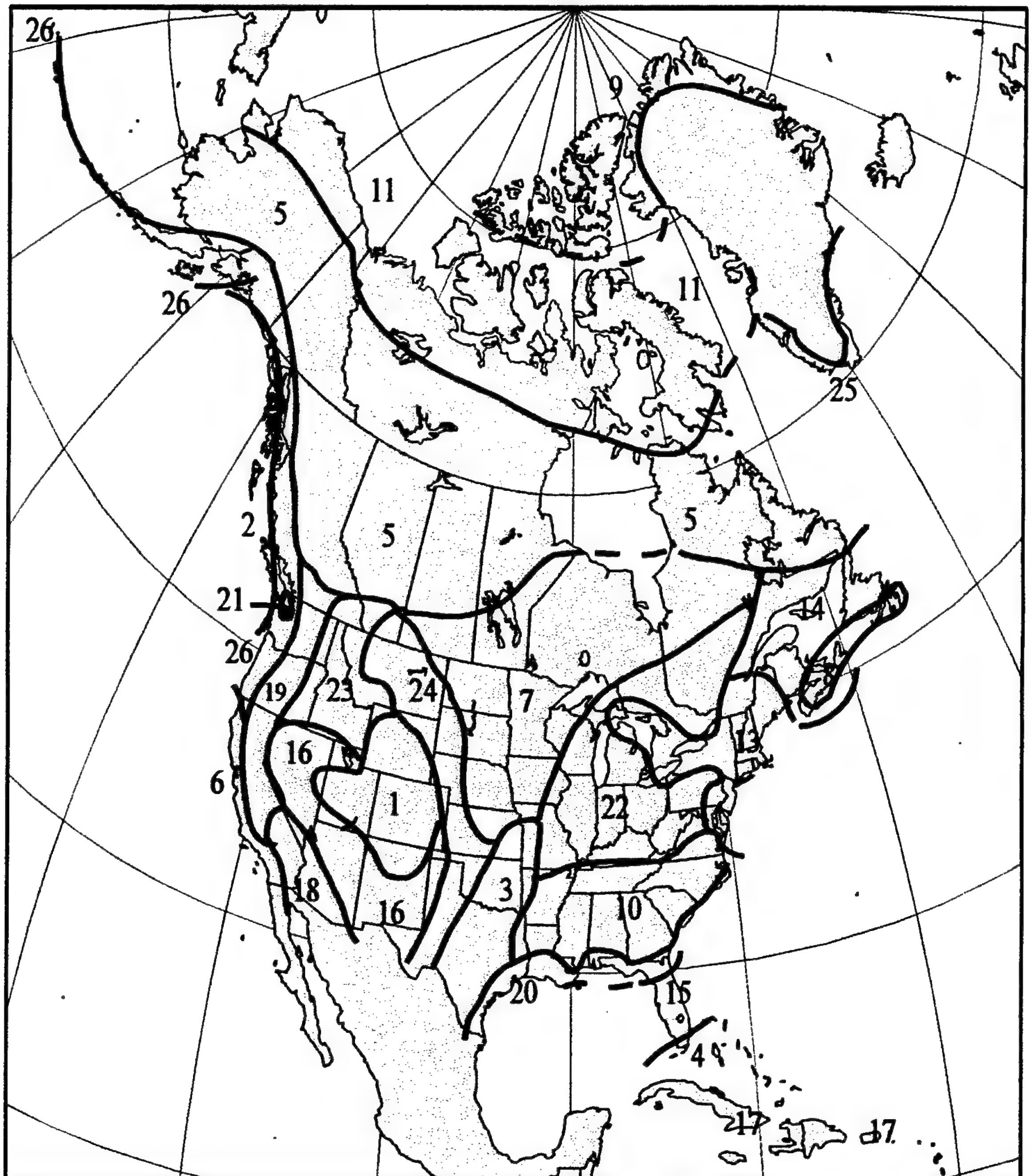

FIGURE 44. NORTH AMERICA TEMPERATURE FREQUENCY GROUPS FOR APRIL

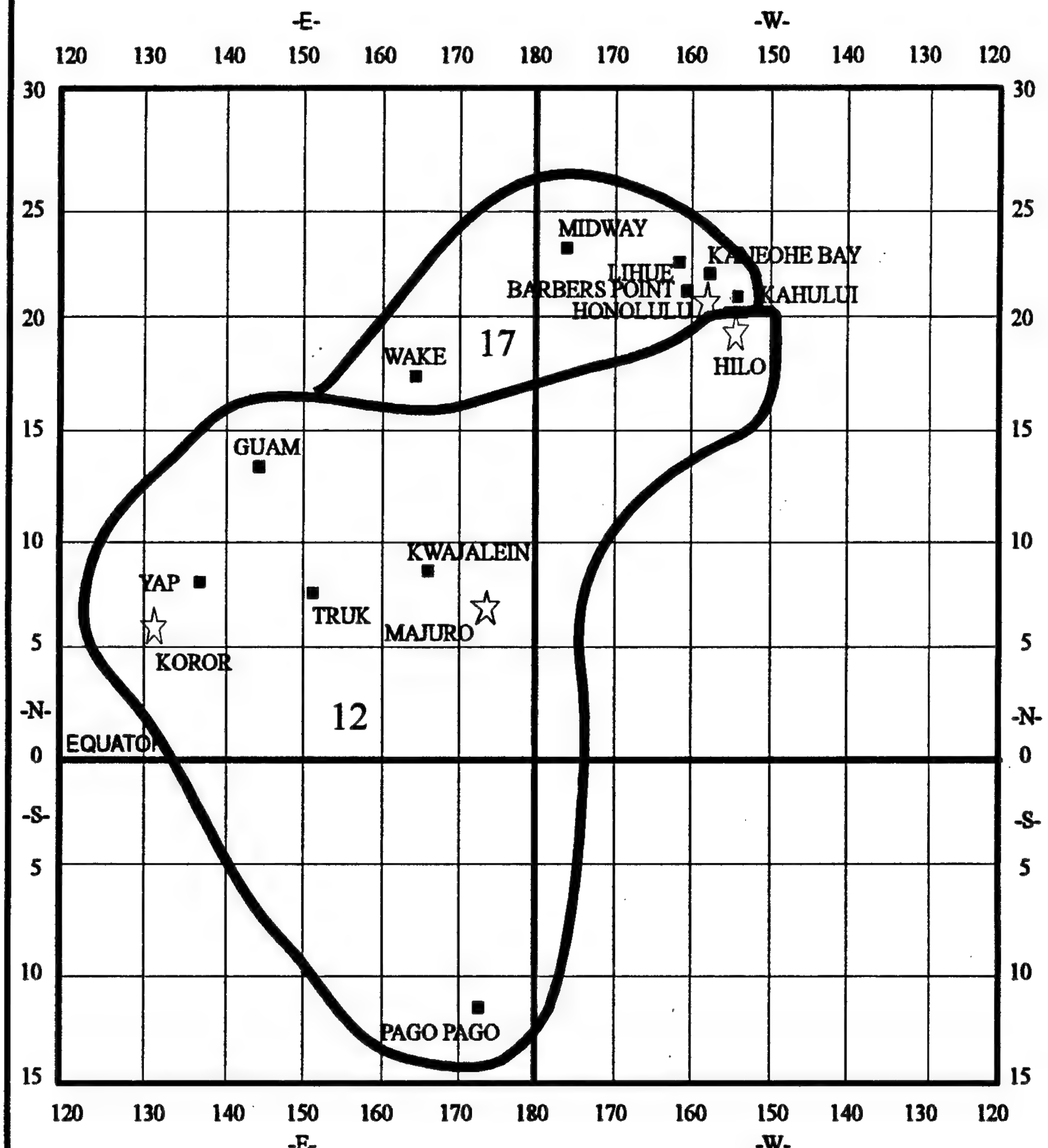

FIGURE 45. PACIFIC ISLANDS TEMPERATURE FREQUENCY GROUPS FOR APRIL

type. In Canada, the Dfc/ET (tree line) boundary is closely approximated by the boundary between Groups 5 and 11

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The Pacific islands are divided into two groups with latitude and P/E being the two primary discriminating variables.

Figures 46 and 47 show the group mean April skewness for North America and the Pacific islands, respectively. One noticeable feature of the North America map is that groups that are positively skewed now far outnumber those with a negative skew. About 75 percent of the groups are now positively skewed (in March, this figure was less than 50 percent), an indication that milder conditions are returning. In fact, isotherm migration northward is greater in April than for any other month (Ludlum, 1982). The sun is rapidly getting higher in the sky each day. For example, on March 1st at the Arctic Circle the sun is approximately 15° above the horizon and the day is approximately 9.5 hours long. By April 15th, the sun at the Arctic Circle has reached roughly 35° above the horizon and the length of day has increased to over 15 hours (Thomas, 1953). In the eastern portions of the U.S, the mean boundary between the mT and cP/cA air masses has risen from 35°N to 40°N (Bryson and Hare, 1974).

The coastal areas of the Pacific still have high positive skews. In addition to coastal California, the entire Pacific coast up through the Aleutians is now maintaining a positive skew. Bryson and Hare (1974) show during April the mean boundary between the cold continental air masses and maritime polar (mP) air has migrated inland away from the Pacific coast, thus allowing a further penetration of mP air. Interior portions of Washington/Oregon and also Idaho have high positive skewness. The semi-permanent high that occupies the high basin areas in this regions during winter and early spring is beginning to recede. The High Arctic is once again strongly positive, however its areal extent has receded to practically north of 70°N latitude. Other strongly positive groups appear along the northeastern coastal areas of the U.S. and in the Canadian Maritime Provinces. Once again, the boundary between the continental and mT air masses to the south is retreating northward, permitting warmer air to push farther into the higher latitudes. The prevailing winds during April in these regions are shifting from their wintertime west-northwesterly flow to a south-southwesterly pattern -- a pattern that will continue through early autumn. The two groups encompassing the Pacific islands are both slightly positive.

Areas of high negative skew remain through most of central portions of Canada, although the southern boundary has begun moving northward. Southern Florida, as it had throughout the winter months and during March, remains strongly negative.

April group means for the attribute variables appear in Table 29, group mean normalized temperatures in Table 30, discriminant functions in Table 31, curve-fitting equations in Table 32, and percent probabilities by frequency level in Table 33.

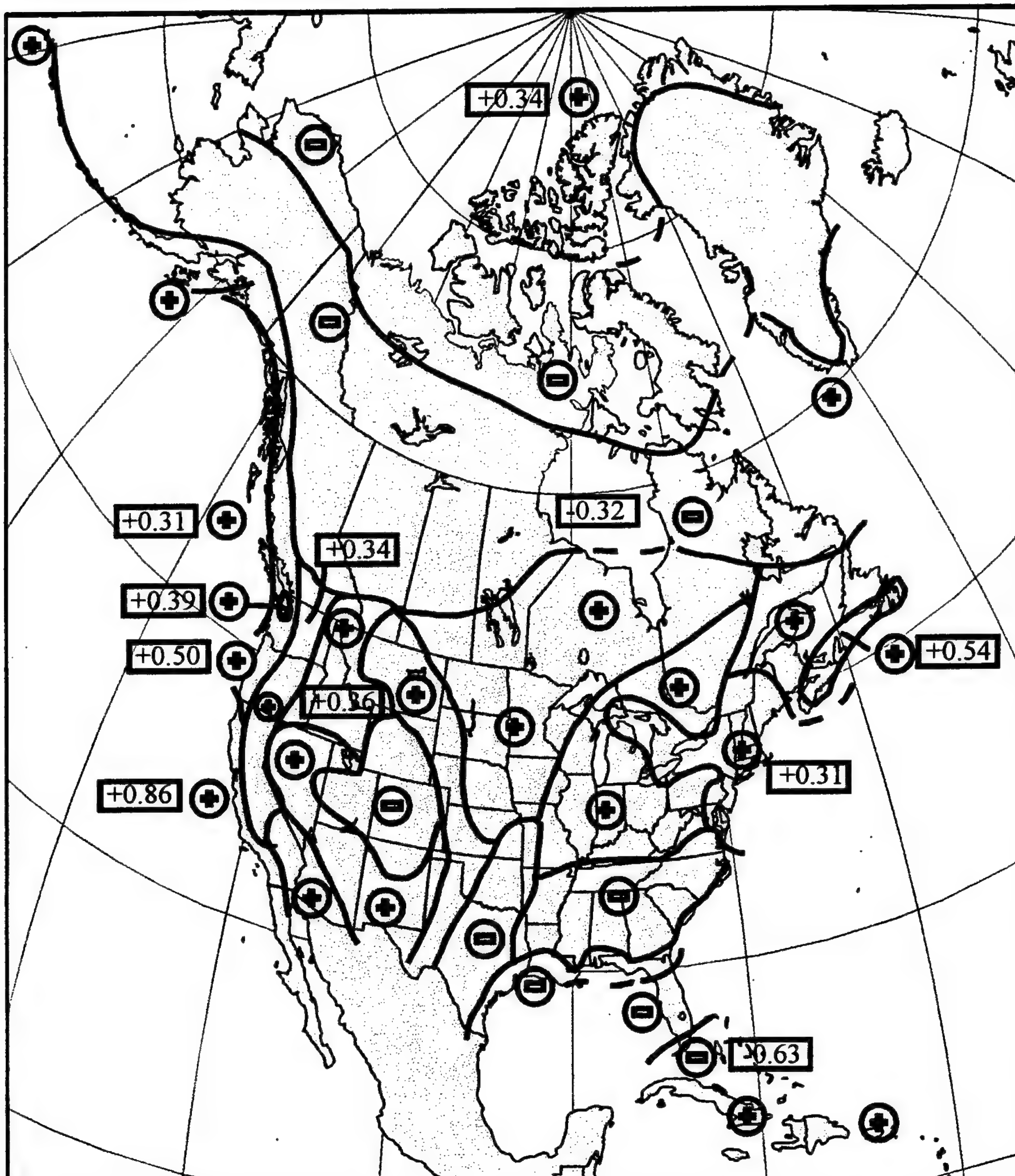

FIGURE 46. NORTH AMERICA TEMPERATURE FREQUENCY GROUP SKEWNESS FOR APRIL

(+) = POSITIVE SKEW (−) = NEGATIVE SKEW

[ ] = VALUES >/= 0.3 OR </= -0.3

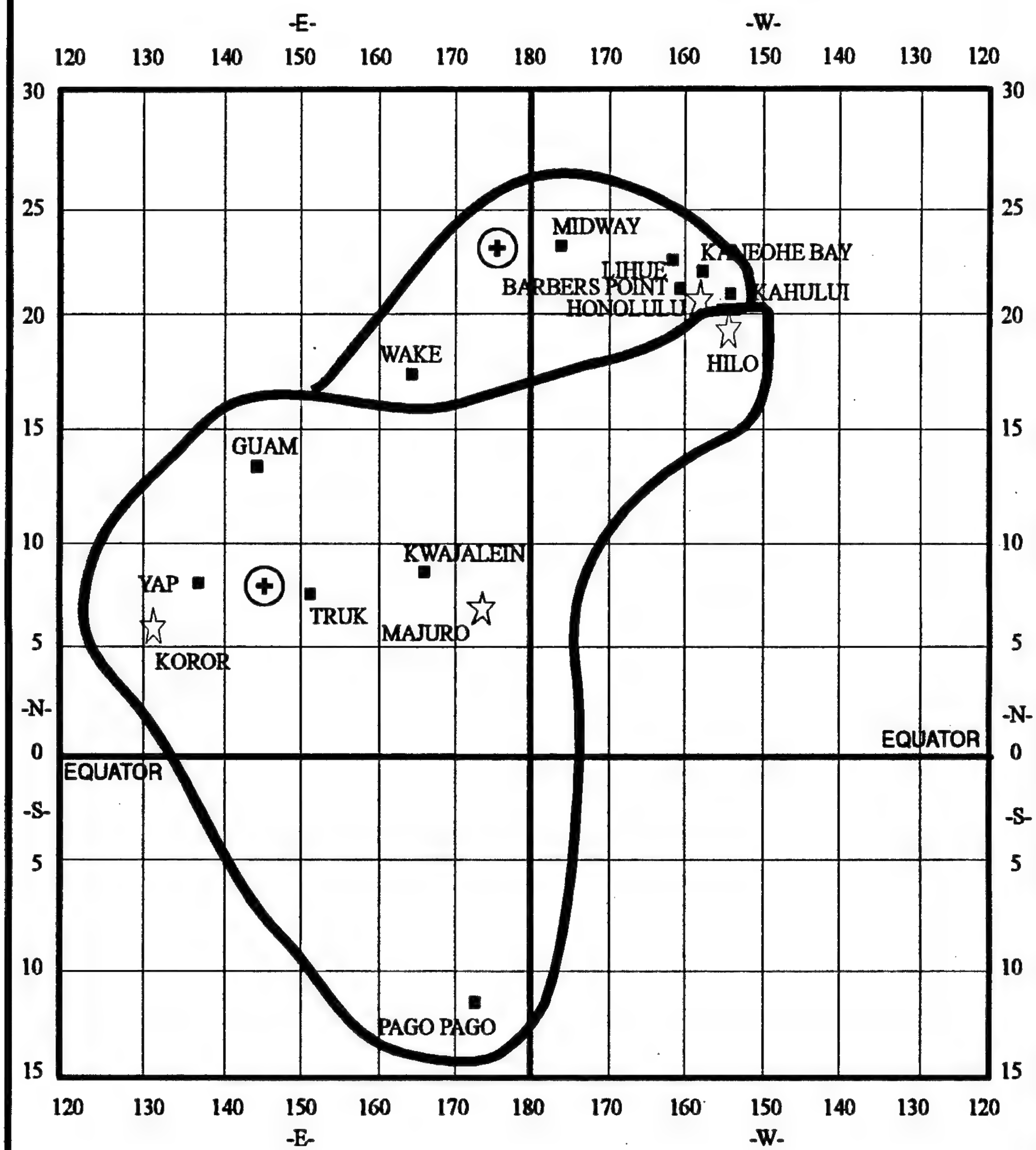

FIGURE 47. PACIFIC ISLANDS TEMPERATURE FREQUENCY GROUP SKEWNESS FOR APRIL

⊕ = POSITIVE SKEW ⊖ = NEGATIVE SKEW

☐ = VALUES >/= 0.3 OR </= -0.3

extent has receded to practically north of 70°N latitude. Other strongly positive groups appear along the northeastern coastal areas of the U.S. and in the Canadian Maritime Provinces. Once again, the boundary between the continental and mT air masses to the south is retreating northward, permitting warmer air to push farther into the higher latitudes. The prevailing winds during April in these regions are shifting from their wintertime west-northwesterly flow to a south-southwesterly pattern -- a pattern that will continue through early autumn. The two groups encompassing the Pacific islands are both slightly positive.

Areas of high negative skew remain through most of central portions of Canada, although the southern boundary has begun moving northward. Southern Florida, as it had throughout the winter months and during March, remains strongly negative.

April group means for the attribute variables appear in Table 29, group mean normalized temperatures in Table 30, discriminant functions in Table 31, curve-fitting equations in Table 32, and percent probabilities by frequency level in Table 33.

May -- Model accuracy in May jumps from April's value of 64 percent of all stations having no error to approximately 83 percent. A little over 96 percent of all generated levels were within the ±2.0°C tolerance range. During May the sun moves higher in the sky and daytime temperatures surge upward. However, nights early in the month are generally cool and may be frosty in more northern locations (Ludlum, 1982). The Pacific high has migrated northward to about 32°N (U.S.-Mexican border). The Azores-Bermuda high has expanded both east-west and north-south, with its mean position at 40°N. May is second to April in the northward movement of the isotherms. The mean boundary between the cP and mT air masses has now moved to the north of 45°N and now cuts across northern portions of the Great Lakes (Bryson and Hare, 1974)

Figure 48 shows the May temperature frequency group patterns for North America and Figure 49 shows the same for the islands in the Pacific Ocean. May is comprised of 33 groups.

The temperature frequency patterns of May are similar to those of April, with an east-west axis in the eastern U.S., a north-south axis in the western U.S., and Groups 3 and 21 encompassing the transitional steppe. The west coast of the U.S. is once again divided into coastal California and those coastal areas possessing a Marine West Coast climate type further to the north. Canada's pattern remains fairly consistent with a northwest-to- southeast bulge. The bulge, consisting of Groups 9 and 24, is fairly close to the mean boundary between the mT and cP air masses as discussed by Bryson and Hare (1974). The Pacific islands are divided primarily by latitude, with P/E being another important discriminating variable.

Table 29. Group Means for April

Group	Station Count	Latitude	Elevation	P/E	Continentality	Temperature Range Monthly	Temperature Range Daily	Normalized Mean Daily Max Teap	Normalized Mean Daily Min Temp
1	7	39.45	5507	25.8	43.5	80.8	26.8	70.6	37.0
2	2	53.74	104	338.0	11.8	61.5	16.5	57.5	30.5
3	6	35.29	1012	51.5	46.8	78.2	23.0	67.4	37.9
4	2	25.18	8	59.7	10.6	47.5	12.0	78.5	53.3
5	6	58.98	578	55.4	42.4	95.0	19.0	67.8	47.9
6	9	34.79	51	21.3	5.8	57.4	15.2	47.4	21.0
7	13	43.97	1272	53.7	54.9	96.8	23.6	62.4	37.8
8	4	45.94	297	187.6	33.4	65.3	13.5	49.4	28.3
9	2	79.07	0	22.0	39.4	74.5	10.0	49.0	35.5
10	21	34.13	528	88.6	35.6	67.4	24.7	71.3	34.6
11	4	67.16	402	42.1	40.1	76.3	14.3	60.8	42.1
12	5	10.70	62	147.9	-9.9	23.4	10.2	72.8	29.1
13	24	41.60	301	100.8	41.8	77.8	20.0	56.6	30.7
14	3	45.57	214	151.7	28.7	52.3	11.3	59.3	37.1
15	7	28.76	36	70.5	22.1	58.3	21.3	76.2	39.6
16	8	37.52	4097	20.5	40.4	77.6	29.9	67.8	29.3
17	7	21.86	43	39.1	-0.1	31.1	11.7	71.6	34.3
18	5	33.99	1669	7.2	40.3	69.8	29.4	68.2	26.0
19	5	39.84	623	25.3	30.4	68.2	27.6	62.2	21.7
20	12	29.75	77	73.5	31.3	64.2	19.1	71.5	41.6
21	2	48.50	54	57.2	8.7	48.0	14.5	57.4	27.1
22	23	40.31	762	87.7	44.8	76.6	21.4	63.0	34.8
23	6	46.31	3306	39.8	38.3	74.2	23.8	59.0	26.8
24	10	42.78	3271	30.7	44.4	88.8	26.1	64.7	35.2
25	3	63.50	147	106.4	12.0	52.7	8.7	57.4	41.0
26	2	45.54	102	141.6	13.0	59.5	19.5	54.2	21.7
ALL	198	39.32	985	72.6	34.1	70.8	20.8	64.1	34.0

Table 30. Group Mean Normalized Temperatures: April

Group	Frequency Levels																			
	0	0.001	0.005	0.01	0.03	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	0.95	0.97	0.99	0.995	0.999	1.0
1	0	10.16	17.85	21.06	26.14	28.85	33.11	38.79	43.26	47.40	51.45	55.80	60.58	66.35	74.00	79.51	82.64	87.56	89.63	92.95	100
2	0	7.26	13.36	16.77	22.23	25.04	29.40	34.58	37.87	40.42	42.89	45.48	48.15	51.38	56.90	62.74	66.96	74.55	78.75	88.13	100
3	0	7.80	14.19	17.63	23.20	26.18	31.30	38.11	43.06	47.47	51.46	55.36	59.50	64.30	70.71	75.56	78.49	83.59	86.18	91.16	100
4	0	18.26	27.50	31.65	38.85	42.83	48.90	55.23	58.99	61.59	64.08	66.48	69.16	72.27	76.49	79.89	81.90	85.57	87.37	92.13	100
5	0	9.08	16.96	21.24	28.71	32.99	39.83	47.16	52.00	55.53	58.73	61.70	64.61	67.98	72.98	77.06	79.69	85.05	88.39	93.71	100
6	0	5.23	9.35	11.56	15.22	17.01	20.01	23.46	25.94	28.22	30.51	33.04	36.07	39.88	45.54	51.29	55.86	66.14	72.01	83.66	100
7	0	10.39	17.85	21.21	26.22	28.83	32.68	37.29	40.99	44.39	47.82	51.45	55.48	60.50	67.47	73.13	76.81	83.49	86.59	92.02	100
8	0	3.05	9.59	12.87	18.50	21.29	24.20	27.62	30.42	33.00	35.72	38.66	42.24	46.66	52.70	57.99	62.17	71.37	76.37	84.72	100
9	0	4.33	9.98	12.41	16.26	18.48	22.26	28.05	32.02	36.89	40.89	44.82	49.02	53.67	60.26	66.36	70.62	82.20	86.11	91.60	100
10	0	5.43	10.52	13.37	19.22	22.79	28.77	36.94	42.98	47.76	51.96	56.02	60.44	65.92	73.18	78.39	81.33	86.17	88.42	92.34	100
11	0	2.83	8.02	10.62	18.02	21.45	27.61	34.37	40.00	45.32	50.53	55.64	60.26	65.98	74.96	80.07	83.03	87.42	89.63	95.43	100
12	0	11.71	16.49	19.43	24.64	27.30	31.81	36.63	40.94	44.55	47.96	51.50	56.59	61.70	67.59	71.56	74.68	78.29	80.32	84.54	100
13	0	5.92	11.86	14.62	19.46	21.96	25.90	30.79	34.51	37.82	41.13	44.70	48.76	53.90	61.40	67.89	72.10	79.78	83.90	90.88	100
14	0	9.65	15.12	18.42	24.29	27.36	31.71	35.54	38.67	41.57	44.37	47.48	51.13	55.72	62.24	67.77	71.85	78.80	83.20	89.28	100
15	0	8.35	15.21	18.81	25.55	29.38	35.54	43.12	48.12	52.07	55.75	59.65	63.91	68.74	74.51	78.67	81.04	85.07	87.11	90.87	100
16	0	7.58	12.46	15.24	20.54	23.54	28.13	34.09	38.96	43.32	47.56	52.13	57.19	63.13	70.89	76.43	79.65	84.67	86.92	91.51	100
17	0	8.24	15.00	18.17	24.14	26.87	31.50	36.64	40.65	44.33	48.05	51.95	56.39	61.36	67.55	72.30	74.71	80.09	82.35	87.70	100
18	0	5.52	9.75	12.15	17.15	20.03	24.70	31.07	36.24	40.93	45.80	50.93	56.49	62.67	69.96	75.14	78.41	83.72	86.17	91.28	100
19	0	5.02	8.94	10.94	14.86	17.15	21.08	26.49	30.73	34.64	38.61	43.08	48.11	54.24	62.97	69.84	73.95	80.92	84.23	90.31	100
20	0	8.43	15.37	19.02	25.68	29.64	36.01	43.79	49.11	53.07	56.37	59.40	62.55	66.31	71.37	75.10	77.49	81.79	84.29	89.47	100
21	0	5.87	10.56	13.08	18.06	20.71	25.46	31.03	34.44	36.83	39.44	42.55	45.75	50.02	56.31	62.34	66.63	72.63	76.62	87.53	100
22	0	7.34	12.67	15.29	20.27	23.03	27.27	33.03	37.79	42.23	46.73	51.29	56.11	61.74	69.38	75.48	79.32	85.60	88.37	92.84	100
23	0	5.80	10.96	13.36	17.55	19.94	23.68	28.64	32.60	36.25	39.92	43.78	48.06	53.53	57.38	68.72	73.00	80.43	84.49	90.95	100
24	0	8.86	15.07	17.91	23.59	26.54	30.88	36.07	40.07	43.81	47.59	51.58	55.88	61.38	69.10	75.29	78.90	84.90	87.86	92.36	100
25	0	2.32	6.70	9.75	15.88	19.14	25.09	33.67	39.89	44.27	48.73	52.45	56.24	60.92	67.46	72.00	74.71	80.29	85.06	92.49	100
26	0	5.11	8.96	10.77	15.38	18.08	22.63	28.01	31.12	33.82	36.61	39.61	42.91	46.96	53.45	59.34	63.67	72.03	75.68	84.43	100

Table 31. Discriminant Function Values: April

Function value = (a x lat) + (b x elev) + (c x P/E) + (d x K) + (e x mrange) + (f x drange) + (g x nmax) + (h x nmin) + constant

Group	a	b	c	d	e	f	g	h	constant
1	4.393	0.032	-0.129	2.223	7.225	-24.674	24.329	-17.614	-718.53
2	6.336	-0.004	0.985	-0.406	6.583	-19.182	20.889	-16.505	-730.36
3	3.646	0.005	-0.017	2.195	7.532	-24.065	23.350	-16.982	-603.89
4	3.037	0.002	-0.085	0.253	7.125	-25.444	23.686	-15.157	-581.97
5	7.085	0.000	-0.165	1.348	7.903	-25.862	25.126	-18.000	-786.72
6	5.042	-0.002	-0.192	-0.362	7.552	-26.294	23.151	-19.496	-448.59
7	4.241	0.006	-0.016	2.475	8.201	-25.339	24.039	-18.105	-672.93
8	4.889	0.001	0.423	1.238	7.351	-24.413	22.353	-18.340	-543.06
9	11.370	-0.004	-0.487	0.876	6.622	-26.531	24.675	-19.733	-832.82
10	4.149	0.002	0.119	1.493	7.312	-23.255	23.635	-17.410	-607.00
11	9.234	-0.001	-0.320	1.143	6.771	-25.190	24.415	-18.128	-768.75
12	1.181	0.006	0.246	-0.318	11.243	-43.017	34.363	-29.032	-769.68
13	4.459	0.000	0.147	1.719	7.651	-24.271	22.950	-18.093	-565.06
14	5.573	0.001	0.215	1.014	6.673	-24.153	22.685	-17.091	-554.57
15	3.733	0.000	0.016	0.793	7.737	-25.900	25.124	-18.128	-614.03
16	4.719	0.022	-0.110	1.890	6.852	-22.235	23.092	-17.243	-638.28
17	3.543	0.004	-0.210	-0.127	9.079	-35.630	29.981	-23.787	-636.17
18	4.742	0.009	-0.169	1.820	7.218	-23.714	24.112	-18.627	-610.25
19	5.982	0.001	-0.136	0.973	7.106	-23.126	23.670	-19.047	-587.91
20	3.208	0.001	0.039	1.357	7.606	-25.094	23.871	-16.967	-578.38
21	7.710	-0.002	-0.191	-0.380	6.947	-26.422	24.772	-20.046	-597.58
22	4.362	0.003	0.095	1.969	7.468	-23.965	23.211	-17.507	-595.75
23	5.998	0.018	-0.123	1.618	7.088	-24.597	23.893	-18.953	-620.75
24	4.778	0.017	-0.101	1.961	7.343	-23.313	23.204	-17.129	-646.03
25	9.372	-0.003	-0.092	-0.520	5.319	-20.622	21.016	-15.004	-638.52
26	6.601	-0.002	0.240	-0.137	6.936	-23.538	23.061	-18.930	-569.11

INPUT VARIABLES
lat = latitude
elev = elevation
P/E = Precipitation Effectiveness Index
K = Continentality
mrange = monthly temperature range
drange = daily temperature range
nmax = normalized mean daily maximum temperature
nmin = normalized mean daily minimum temperature

Table 32. Temperature Frequency Equations: April

Group	If Input Normalized Temperature (T) < 50th Percentile Normalized Temperature (T)	Maximum Error E1	Maximum Error E2	50th Percentile Normalized T	Group	If Input Normalized Temperature (T) > 50th Percentile Normalized Temperature (T)	Maximum Error E3	Maximum Error E4
1	F=0.005-0.00190599*T+1.1612e-005*T^2+4.22541e-006*T^3	0.009	0.013	51.45	1	F=-2.013+0.0754197*T-0.000585343*T^2+1.32267e-006*T^3	0.002	0.003
2	F=-0.003+0.00384131*T-0.000434635*T^2+1.44227e-005*T^3	0.006	0.005	42.89	2	F=-7.865+0.425347*T-0.00766889*T^2+6.14362e-005*T^3-1.8417e-007*T^4	0.008	0.003
3	F=0.004-0.00160178*T+4.88814e-005*T^2+3.34576e-006*T^3	0.005	0.006	51.46	3	F=-3.206+0.122181*T-0.00116357*T^2+3.62065e-006*T^3	0.007	0.006
4	F=0.000-0.00457393*T+0.000450872*T^2-1.43773e-005*T^3+1.61585e-007*T^4	0.003	0.005	64.08	4	F=-13.542+0.456774*T-0.00477387*T^2+1.66013e-005*T^3	0.006	0.003
5	F=-0.004+0.00293522*T-0.000224045*T^2+5.43059e-006*T^3	0.007	0.006	58.73	5	F=-8.710+0.309823*T-0.00329155*T^2+1.16422e-005*T^3	0.009	0.003
6	F=0.003-0.000300723*T-0.000246982*T^2+2.63438e-005*T^3	0.005	0.011	30.51	6	F=-2.922+0.206787*T-0.00408024*T^2+3.55502e-005*T^3-1.15047e-007*T^4	0.001	0.003
7	F=0.003+0.000335818*T-0.00018274*T^2+8.35624e-006*T^3	0.006	0.014	47.82	7	F=-3.033+0.126538*T-0.00132289*T^2+4.60732e-006*T^3	0.003	0.005
8	F=0.002+0.00078338*T-0.00031316*T^2+1.94438e-005*T^3	0.006	0.016	35.72	8	F=-2.005+0.113156*T-0.00140702*T^2+5.76281e-006*T^3	0.004	0.012
9	F=0.008-0.00613895*T+0.000506612*T^2-1.44342e-006*T^3	0.009	0.016	40.89	9	F=-2.233+0.109173*T-0.00122829*T^2+4.59841e-006*T^3	0.008	0.005
10	F=0.002-0.00102115*T+9.22765e-005*T^2+2.16286e-006*T^3	0.001	0.001	51.96	10	F=-2.523+0.0942781*T-0.000809273*T^2+2.18588e-006*T^3	0.002	0.004
11	F=0.007-0.00311091*T+0.000244289*T^2+2.68208e-007*T^3	0.007	0.009	50.53	11	F=-1.548+0.0584176*T-0.000382422*T^2+5.27853e-007*T^3	0.009	0.003
12	F=0.003-0.00038408*T-9.77761e-005*T^2+6.80825e-006*T^3	0.005	0.010	47.96	12	F=-2.299+0.0929868*T-0.000836431*T^2+2.36193e-006*T^3	0.012	0.012
13	F=0.004-0.0018624*T+2.54664e-005*T^2+7.76444e-006*T^3	0.005	0.011	41.13	13	F=-2.154+0.105721*T-0.00118357*T^2+4.41873e-006*T^3	0.001	0.003
14	F=-0.000+0.00349091*T-0.000432511*T^2+1.38247e-005*T^3	0.006	0.012	44.37	14	F=-3.136+0.14139*T-0.00160991*T^2+6.09779e-006*T^3	0.002	0.004
15	F=-0.001+0.000985924*T-0.000109364*T^2+4.54607e-006*T^3	0.001	0.003	55.75	15	F=-3.017+0.101071*T-0.000776508*T^2+1.67042e-006*T^3	0.007	0.01
16	F=0.006-0.00313777*T+0.000173832*T^2+2.41473e-006*T^3	0.008	0.009	47.56	16	F=-1.612+0.0666432*T-0.000526346*T^2+1.20848e-006*T^3	0.003	0.005
17	F=0.004-0.000737296*T-6.65498e-005*T^2+6.29674e-006*T^3	0.006	0.013	48.05	17	F=-2.684+0.109421*T-0.00106366*T^2+3.37498e-006*T^3	0.009	0.009
18	F=0.007-0.00434886*T+0.000351534*T^2-3.89189e-007*T^3	0.007	0.008	45.80	18	F=-1.113+0.0479813*T-0.000291819*T^2+2.27452e-007*T^3	0.008	0.005
19	F=0.007-0.0050929*T+0.000468889*T^2-1.91732e-008*T^3	0.008	0.008	38.61	19	F=-1.242+0.068177*T-0.00068769*T^2+2.30026e-006*T^3	0.002	0.001
20	F=-0.002+0.00143958*T-0.000129489*T^2+4.62557e-006*T^3	0.002	0.004	56.37	20	F=-6.961+0.252951*T-0.00266975*T^2+9.36112e-006*T^3	0.008	0.005
21	F=-0.003+0.0027781*T-0.000330075*T^2+1.47941e-005*T^3	0.004	0.007	39.44	21	F=-2.571+0.130328*T-0.00157685*T^2+6.31113e-006*T^3	0.007	0.008
22	F=0.007-0.00436149*T+0.000261288*T^2+1.34099e-006*T^3	0.010	0.011	46.73	22	F=-1.894+0.0805125*T-0.000728527*T^2+2.12512e-006*T^3	0.005	0.003
23	F=0.007-0.00437788*T+0.000282073*T^2+3.60542e-006*T^3	0.009	0.011	39.92	23	F=-1.865+0.0951077*T-0.00105596*T^2+3.91542e-006*T^3	0.009	0.003
24	F=0.004-0.00118132*T-3.42855e-005*T^2+5.97174e-006*T^3	0.006	0.014	47.59	24	F=-2.456+0.102968*T-0.00101875*T^2+3.34611e-006*T^3	0.004	0.008
25	F=0.001-0.000453007*T+0.000119838*T^2+2.06227e-006*T^3	0.001	0.005	48.73	25	F=-3.391+0.137844*T-0.00143467*T^2+4.94991e-006*T^3	0.007	0.005
26	F=-0.000+0.000977879*T-0.00015741*T^2+1.38928e-005*T^3	0.002	0.009	36.61	26	F=-2.175+0.119402*T-0.00148449*T^2+6.0832e-006*T^3	0.011	0.012

E1 = Maximum Prediction Error When Computed Frequency < 5%
E2 = Maximum Prediction Error When Computed Frequency Between 5 - 50%
E3 = Maximum Prediction Error When Computed Frequency Between 50 - 95%
E4 = Maximum Prediction Error When Computed Frequency >95%

Table 33. Percent Probability of Predicted Temperatures >2.0C at Each Frequency Level by Group

Month: April

	STANDARDIZED FREQUENCY LEVELS																			% OF ALL >
GROUP	0.001	0.005	0.01	0.03	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	0.95	0.97	0.99	0.995	0.999	2.0C
1	0	34	34	34	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7.9
2	0	0	0	50	50	50	50	50	50	50	50	50	50	0	0	0	0	0	0	18.4
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	14	0	1.5
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
5	0	0	0	0	0	0	0	17	17	17	17	34	17	0	0	0	0	0	0	5.3
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
7	22	22	15	15	15	22	8	8	8	8	8	8	0	8	0	0	0	8	0	9.3
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25	25	25	25	25	6.6
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
13	4	4	0	0	0	0	0	0	0	0	0	4	4	8	8	8	4	4	8	2.4
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
15	0	0	0	0	0	0	0	0	0	0	0	0	13	13	13	13	13	13	0	4.0
16	13	0	0	0	0	0	13	13	13	0	0	0	0	0	0	0	0	0	0	2.6
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
20	0	0	0	0	0	0	8	8	8	8	8	8	8	8	8	8	8	0	0	4.4
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	0	2.6
22	0	0	0	0	0	0	0	0	4	4	4	9	9	4	4	4	0	0	0	1.9
23	0	0	0	0	0	0	0	0	0	0	0	0	0	17	17	17	17	17	0	4.4
24	11	22	22	11	22	22	22	22	11	0	0	0	0	0	0	0	0	0	0	7.6
25	0	0	0	0	0	0	33	33	0	0	0	0	0	0	0	0	0	0	0	3.5
26	0	0	0	0	0	0	0	0	0	0	0	0	0	33	33	33	0	0	0	5.3

May -- Model accuracy in May jumps from April's value of 64 percent of all stations having no error to approximately 83 percent. A little over 96 percent of all generated levels were within the +/-2.0°C tolerance range. During May the sun moves higher in the sky and daytime temperatures surge upward. However, nights early in the month are generally cool and may be frosty in more northern locations (Ludlum, 1982). The Pacific high has migrated northward to about 32°N (U.S.-Mexican border). The Azores-Bermuda high has expanded both east-west and north-south, with its mean position at 40°N. May is second to April in the northward movement of the isotherms. The mean boundary between the cP and mT air masses has now moved to the north of 45°N and now cuts across northern portions of the Great Lakes (Bryson and Hare, 1974)

Figure 48 shows the May temperature frequency group patterns for North America and Figure 49 shows the same for the islands in the Pacific Ocean. May is comprised of 33 groups.

The temperature frequency patterns of May are similar to those of April, with an east-west axis in the eastern U.S., a north-south axis in the western U.S., and Groups 3 and 21 encompassing the transitional steppe. The west coast of the U.S. is once again divided into coastal California and those coastal areas possessing a Marine West Coast climate type further to the north. Canada's pattern remains fairly consistent with a northwest-to- southeast bulge. The bulge, consisting of Groups 9 and 24, is fairly close to the mean boundary between the mT and cP air masses as discussed by Bryson and Hare (1974). The Pacific islands are divided primarily by latitude, with P/E being another important discriminating variable.

Figures 50 and 51 show the group mean May skewness for North America and the Pacific islands, respectively. About two-thirds of the groups have a positive skew. Like April, high positive skewness continues to exist during May throughout the entire Pacific coast of North America and in the northeast U.S. and the Canadian Maritimes where the surface air flow is becoming more southwesterly. Although the High Arctic is showing a negative skew, stations such as Nord, Greenland, are still registering positive skewness. The vast portion of CONUS south of about 35°N latitude also is negative, although only slightly -- the highest negative skew in this area is -0.05, thus extremely close to a normal distribution. The Pacific islands exhibit a north-south pattern of negative-positive-negative skewness, but the skewness of all these groups hovers quite close to zero.

May group means for the attribute variables appear in Table 34, group mean normalized temperatures in Table 35, discriminant functions in Table 36, curve-fitting equations in Table 37, and percent probabilities by frequency level in Table 38.

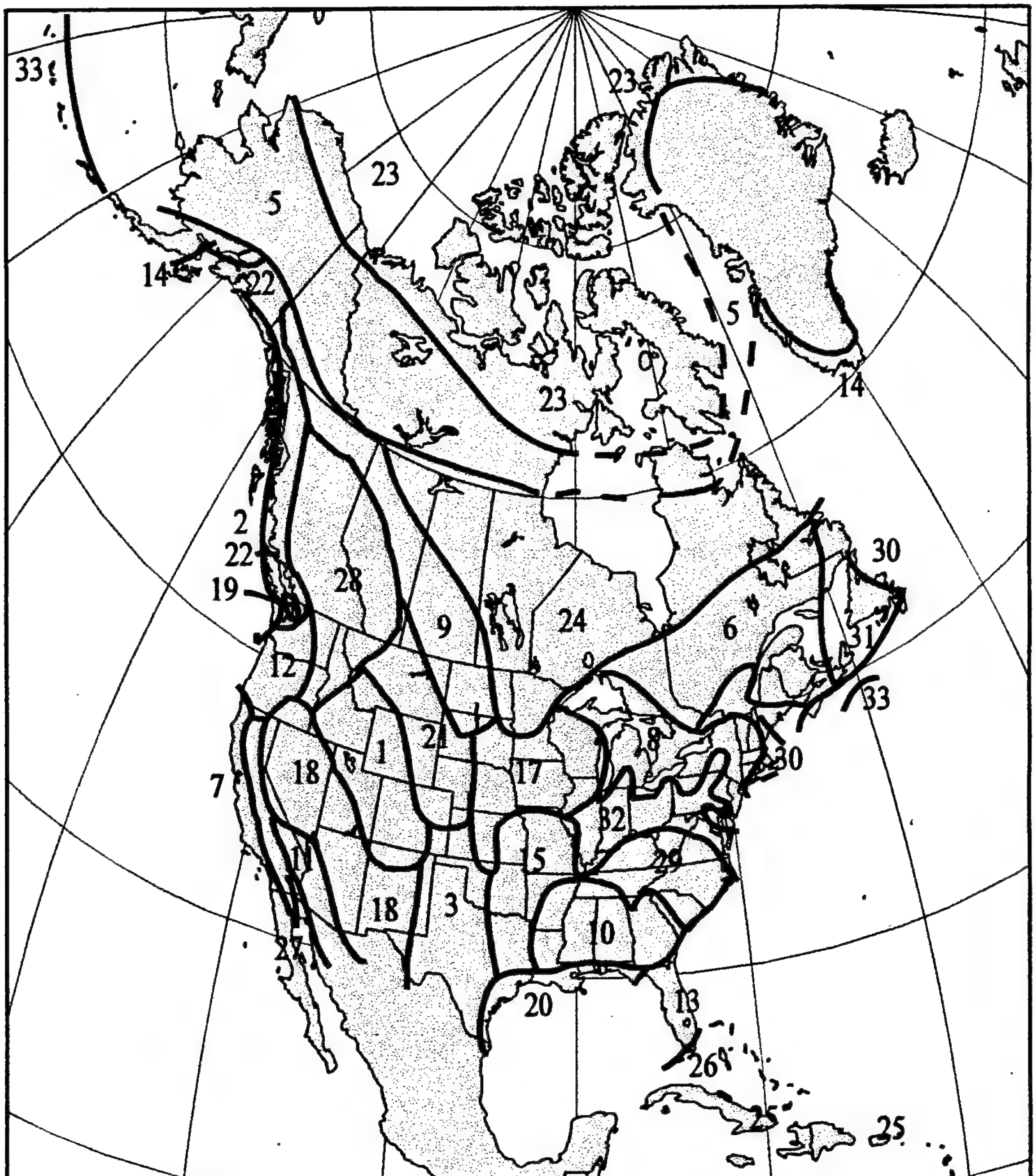

FIGURE 48. NORTH AMERICA TEMPERATURE FREQUENCY GROUPS FOR MAY

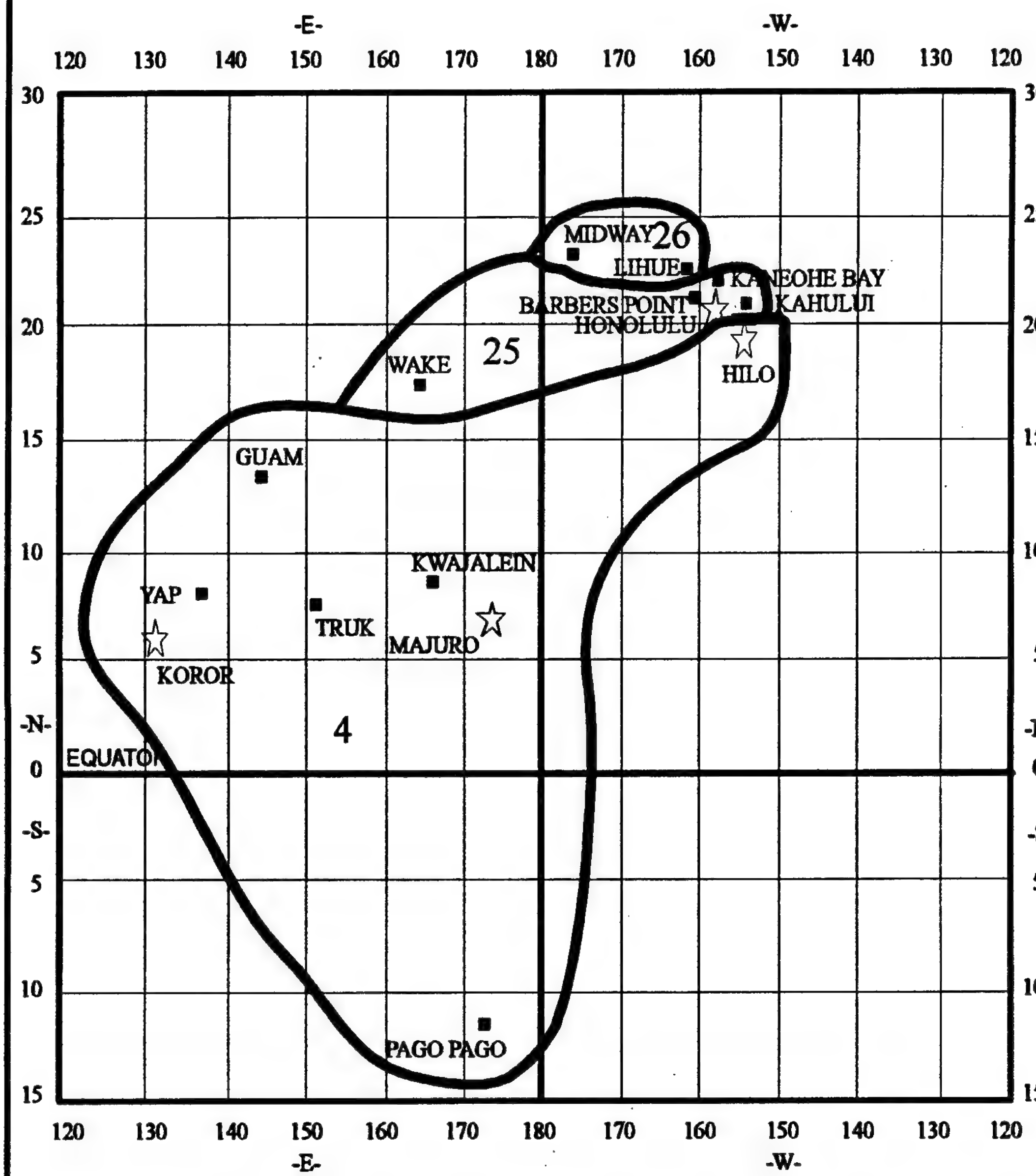

FIGURE 49. PACIFIC ISLANDS TEMPERATURE FREQUENCY GROUPS FOR MAY

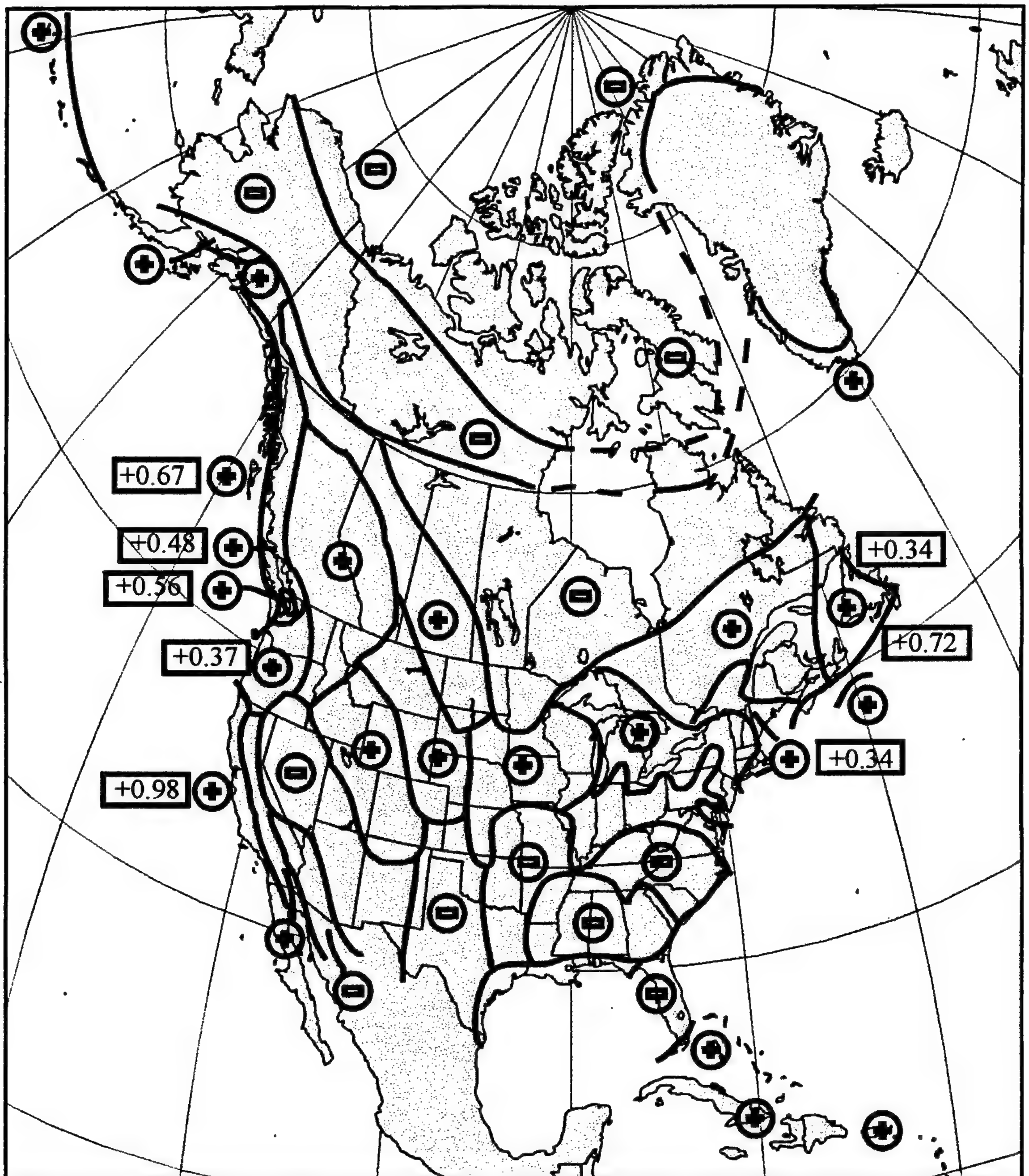

FIGURE 50. NORTH AMERICA TEMPERATURE FREQUENCY GROUP SKEWNESS FOR MAY

⊕ = POSITIVE SKEW ⊖ = NEGATIVE SKEW

▭ = VALUES >/= 0.3 OR </= -0.3

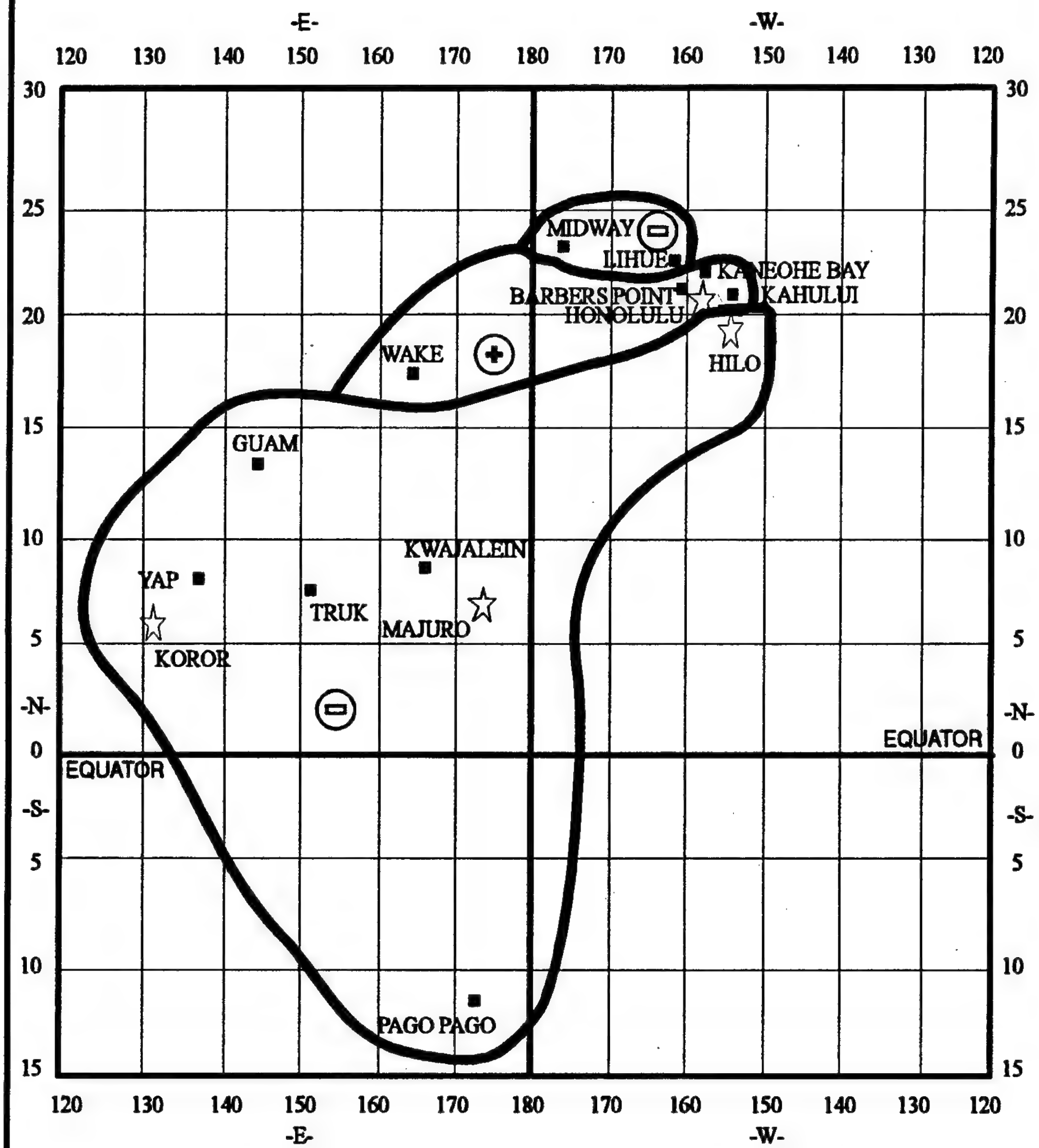

FIGURE 51. PACIFIC ISLANDS TEMPERATURE FREQUENCY GROUP SKEWNESS FOR MAY

(+) = POSITIVE SKEW (−) = NEGATIVE SKEW

= VALUES >/= 0.3 OR </= -0.3

Table 34. Group Means for May

Group	Station Count	Latitude	Elevation	P/E	Continentality	Temperature Range Monthly	Temperature Range Daily	Normalized Mean Daily Max Team	Normalized Mean Daily Min Temp
1	8	40.05	5215	27.9	43.8	71.0	26.9	68.0	30.1
2	2	53.74	104	338.0	11.8	60.5	16.0	49.6	23.2
3	4	33.69	2649	26.2	43.3	74.0	26.0	69.6	34.4
4	5	10.70	62	147.9	-9.9	23.0	10.0	75.6	32.2
5	5	62.85	226	41.7	41.3	80.4	18.2	65.8	43.2
6	2	45.40	238	160.3	44.0	62.5	17.5	58.3	30.2
7	9	34.79	51	21.3	5.8	55.9	14.1	46.3	21.4
8	19	42.15	519	96.0	42.7	67.8	22.2	63.0	30.3
9	3	47.13	2058	29.8	55.0	85.0	25.7	62.1	31.8
10	14	32.62	365	91.1	34.7	58.6	22.9	74.7	35.7
11	4	34.33	2035	8.3	40.7	70.3	29.8	71.1	28.8
12	3	44.62	853	58.3	26.1	75.7	27.7	58.5	22.0
13	5	28.50	36	66.4	20.2	49.8	19.4	74.7	35.7
14	4	64.27	432	101.2	18.4	47.0	8.5	58.2	40.0
15	6	36.03	797	63.8	47.0	64.2	21.0	72.2	39.5
16	1	26.58	15	67.1	16.1	47.0	22.0	78.7	31.9
17	11	41.73	1121	61.9	53.0	72.5	23.2	66.0	34.0
18	6	37.63	4216	16.6	39.1	77.5	32.0	71.4	30.1
19	2	48.50	54	57.2	8.7	55.0	14.0	52.0	26.5
20	10	29.56	51	68.1	31.4	53.1	17.7	73.1	39.7
21	7	43.76	3522	31.8	44.2	78.6	25.6	65.4	32.8
22	4	46.70	152	174.0	18.9	51.5	14.3	53.5	25.7
23	4	73.30	36	26.8	40.8	59.5	9.3	62.2	46.6
24	3	47.35	1127	53.9	57.1	85.3	24.3	62.0	33.5
25	5	20.57	34	32.5	-1.4	28.6	12.8	71.6	27.3
26	4	25.13	37	57.7	6.8	31.8	10.3	73.3	40.8
27	4	35.73	239	15.0	32.7	71.5	30.0	67.1	25.2
28	5	49.45	2888	43.1	35.4	71.6	24.2	59.7	25.9
29	13	35.31	715	87.2	35.6	65.2	23.1	73.5	38.1
30	6	43.76	192	119.6	40.9	63.8	18.7	57.6	28.4
31	3	48.04	171	153.6	38.5	68.0	17.0	45.5	20.5
32	16	39.32	496	88.3	42.9	66.0	21.3	68.4	36.1
33	1	43.93	13	161.5	25.7	34.0	9.0	61.7	35.2
ALL	198	39.32	985	72.6	34.1	62.9	20.8	66.0	32.9

Table 35. Group Mean Normalized Temperatures: May

Group	Frequency Levels																				
	0	0.001	0.005	0.01	0.03	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	0.95	0.97	0.99	0.995	0.999	1.0
1	0	6.05	11.48	14.19	19.24	22.16	26.93	33.10	37.84	42.27	46.63	51.40	56.64	62.76	70.79	76.44	79.62	84.75	87.12	91.27	100
2	0	4.34	7.85	10.10	14.59	17.30	21.39	26.20	29.38	32.00	34.49	37.01	39.72	43.16	48.82	55.12	59.91	71.93	77.47	88.90	100
3	0	6.79	13.20	16.53	22.72	26.06	31.31	37.31	41.72	45.85	49.83	54.00	58.74	64.48	71.59	76.96	79.94	85.45	88.03	93.14	100
4	0	12.95	19.35	21.57	26.96	29.59	33.86	39.51	43.85	47.11	50.30	54.11	58.64	63.51	69.32	73.56	76.02	79.83	82.50	86.14	100
5	0	10.36	19.31	23.88	31.39	34.67	39.31	43.76	47.16	50.29	53.33	56.43	59.85	63.91	69.38	74.02	77.05	82.25	85.17	89.83	100
6	0	2.75	9.23	12.33	18.06	20.85	25.60	30.89	35.18	38.37	41.93	46.19	51.04	55.44	63.87	69.81	73.72	80.96	84.62	90.00	100
7	0	6.77	10.68	12.68	15.82	17.62	20.11	23.16	25.46	27.57	29.76	32.28	35.20	38.72	43.78	48.74	52.54	61.78	68.08	80.94	100
8	0	5.64	10.08	12.77	17.80	20.66	25.45	31.57	36.34	40.72	44.97	49.38	54.13	59.66	67.60	74.03	77.95	84.19	87.02	92.45	100
9	0	6.66	12.09	15.06	20.35	23.04	27.74	33.70	37.83	41.54	45.51	49.53	54.05	59.45	67.16	73.33	76.98	82.64	85.55	92.11	100
10	0	7.05	12.46	15.58	22.43	26.46	32.76	40.16	44.81	48.62	52.43	56.72	61.91	67.56	74.04	78.44	80.98	85.32	87.56	91.74	100
11	0	6.77	12.03	14.93	20.52	23.65	28.77	35.62	41.09	46.01	50.80	55.85	61.22	66.84	73.28	77.92	80.54	85.38	87.96	92.51	100
12	0	5.04	8.73	10.72	15.10	17.73	22.10	27.21	31.11	34.60	38.04	41.73	46.14	51.74	60.23	66.83	70.94	78.06	81.34	87.18	100
13	0	8.21	15.40	18.95	26.02	29.52	34.69	40.35	44.32	47.85	51.55	55.86	60.66	65.68	71.61	75.89	78.58	83.16	85.66	90.22	100
14	0	3.84	10.30	14.76	22.65	26.00	30.70	35.59	39.72	43.33	46.67	50.36	54.42	58.98	65.07	71.06	75.04	81.66	85.13	92.27	100
15	0	7.64	14.54	18.07	24.41	28.12	34.04	41.01	46.03	50.32	54.26	58.20	62.59	67.74	74.43	78.92	81.47	85.54	87.63	91.91	100
16	0	9.66	16.22	18.69	24.82	27.43	32.29	37.72	41.67	45.73	50.56	56.72	62.48	67.93	73.25	77.18	79.06	82.86	85.20	89.68	100
17	0	6.32	11.26	14.12	20.02	23.23	28.37	34.80	39.71	44.10	48.28	52.45	56.98	62.40	69.80	75.51	78.84	84.41	86.95	91.48	100
18	0	8.92	14.58	17.51	22.81	25.72	30.51	36.75	41.71	46.23	50.74	55.54	60.89	66.93	74.22	79.29	82.14	86.70	89.19	93.19	100
19	0	7.50	12.57	15.23	20.04	22.67	25.94	29.23	32.21	34.81	37.37	40.05	43.19	46.86	52.69	57.21	60.78	69.08	74.27	83.07	100
20	0	6.91	14.92	18.48	25.81	30.13	36.25	43.11	47.63	51.19	54.50	57.89	61.70	66.05	71.40	75.18	77.46	81.87	84.16	89.13	100
21	0	8.39	14.04	16.87	21.73	24.56	29.15	34.71	38.80	42.65	46.46	50.53	55.20	60.89	68.97	75.01	78.78	84.45	87.12	91.91	100
22	0	5.30	9.57	11.75	15.99	18.34	21.82	26.54	30.04	33.34	36.74	40.44	43.98	48.86	55.98	61.67	65.38	73.31	78.29	86.99	100
23	0	6.79	11.16	14.40	21.74	26.03	32.12	39.65	45.54	50.25	54.10	57.95	61.71	65.86	71.89	76.21	79.20	84.95	88.48	94.06	100
24	0	7.26	12.88	15.58	19.82	22.66	27.70	34.14	38.35	42.58	46.58	50.57	55.16	59.83	67.00	72.85	76.25	82.25	84.77	89.74	100
25	0	4.87	9.42	11.95	17.96	20.77	25.01	30.53	34.76	38.87	43.28	48.08	53.60	59.09	65.97	71.22	73.95	79.65	82.09	87.54	100
26	0	9.28	15.69	19.30	25.62	29.49	34.43	40.17	44.29	47.65	50.88	54.25	58.20	62.90	68.54	72.89	75.30	79.98	82.88	88.50	100
27	0	6.63	10.91	13.42	17.79	20.18	24.28	29.45	33.95	38.41	43.03	48.23	53.91	60.13	68.36	74.24	77.84	83.36	86.30	92.04	100
28	0	5.55	9.83	11.80	16.32	18.91	23.15	28.68	32.98	36.45	40.53	44.96	49.72	55.75	63.55	70.22	74.47	82.10	85.20	92.66	100
29	0	9.52	15.57	18.87	24.95	28.45	34.23	41.43	46.37	50.33	53.92	57.74	62.28	67.66	74.21	78.95	81.63	86.15	88.37	92.28	100
30	0	4.39	8.80	11.32	15.89	18.55	22.65	27.52	31.70	35.65	39.67	43.72	48.29	53.71	62.25	69.45	73.75	81.88	86.19	92.99	100
31	0	4.13	5.89	8.14	11.69	13.51	16.68	20.76	24.18	27.19	30.27	33.43	36.61	41.55	49.76	57.02	61.55	71.86	76.59	88.03	100
32	0	7.43	13.41	16.24	21.72	24.87	30.07	36.80	41.96	46.58	50.84	54.97	59.38	64.80	72.38	78.15	81.47	86.57	88.88	92.98	100
33	0	15.03	20.33	22.79	26.49	28.69	32.17	37.01	40.94	44.52	48.13	51.72	55.30	60.02	65.99	70.97	74.15	79.91	82.66	88.05	100

Table 36. Discriminant Function Values: May

Function value = (a x lat) + (b x elev) + (c x P/E) + (d x K) + (e x mrange) + (f x drange) + (g x nmax) + (h x nmin) + constant

Group	a	b	c	d	e	f	g	h	constant
1	8.129	0.035	-0.347	-1.558	23.908	-65.845	45.336	-34.757	-1201.22
2	9.498	-0.001	0.744	-1.646	23.951	-66.054	43.638	-35.783	-1237.86
3	7.244	0.017	-0.331	-1.256	24.490	-66.048	45.009	-34.332	-1138.90
4	5.723	0.008	-0.063	-2.661	27.008	-82.842	55.617	-45.543	-1309.30
5	13.038	-0.003	-0.532	-2.014	28.001	-77.842	51.562	-38.564	-1640.61
6	8.530	-0.002	0.145	-0.312	24.515	-69.053	45.272	-36.512	-1130.69
7	8.235	0.000	-0.471	-2.470	24.360	-68.817	45.019	-37.113	-975.35
8	8.563	0.000	-0.110	-0.806	24.316	-67.233	45.349	-35.942	-1123.80
9	8.850	0.010	-0.336	-0.726	26.472	-71.172	47.006	-37.081	-1277.88
10	7.989	0.001	-0.162	-1.317	23.488	-65.882	46.113	-35.250	-1131.83
11	8.013	0.010	-0.430	-1.495	22.710	-61.496	44.016	-33.874	-1080.76
12	9.451	0.001	-0.302	-2.094	23.675	-63.116	44.159	-35.290	-1105.40
13	8.143	0.001	-0.324	-2.059	23.989	-69.077	48.193	-37.022	-1155.00
14	14.080	0.001	-0.378	-2.787	21.488	-64.129	43.966	-31.300	-1295.70
15	8.017	0.004	-0.232	-0.764	24.261	-67.758	45.932	-34.764	-1162.63
16	8.301	0.000	-0.356	-2.315	24.675	-71.967	51.083	-40.193	-1240.50
17	8.327	0.004	-0.212	-0.472	24.850	-68.328	45.769	-35.736	-1171.52
18	8.119	0.027	-0.388	-1.985	22.591	-59.485	42.806	-31.876	-1143.54
19	11.056	-0.002	-0.446	-2.812	23.914	-68.710	46.229	-36.560	-1140.76
20	7.697	0.000	-0.263	-1.371	23.901	-68.244	46.555	-35.251	-1120.52
21	8.689	0.022	-0.353	-1.492	25.305	-68.462	46.155	-35.407	-1241.41
22	9.606	-0.001	0.094	-1.637	23.365	-67.308	44.909	-36.291	-1078.40
23	15.666	-0.005	-0.695	-2.143	24.515	-72.811	48.728	-34.804	-1621.10
24	8.750	0.003	-0.239	-0.415	27.012	-72.656	47.473	-37.616	-1304.31
25	7.998	0.003	-0.560	-2.835	26.561	-82.031	55.931	-46.041	-1306.76
26	8.336	0.004	-0.423	-2.612	22.911	-69.350	47.742	-35.632	-1118.58
27	8.537	-0.004	-0.435	-1.754	22.478	-60.080	43.395	-33.984	-1053.65
28	10.061	0.016	-0.377	-1.870	24.444	-67.670	46.224	-36.454	-1198.83
29	8.180	0.004	-0.172	-1.444	23.858	-65.586	45.471	-34.120	-1158.05
30	8.567	-0.002	-0.021	-0.602	24.579	-68.973	45.507	-36.862	-1105.65
31	8.361	-0.003	0.138	-0.356	25.833	-72.019	45.779	-39.140	-1114.25
32	8.406	0.001	-0.150	-0.899	24.305	-67.399	45.654	-35.093	-1154.12
33	9.905	-0.001	0.022	-1.271	20.825	-63.577	43.203	-32.868	-1028.79

INPUT VARIABLES
lat = latitude
elev = elevation
P/E = Precipitation Effectiveness Index
K = Continentality
mrange = monthly temperature range
drange = daily temperature range
nmax = normalized mean daily maximum temperature
nmin = normalized mean daily minimum temperature

Table 37. Temperature Frequency Equations: May

Group	If Input Normalized Temperature (T) < 50th Percentile Normalized Temperature (T)	Maximum Error E1	Maximum Error E2	50th Percentile Normalized T	Group	If Input Normalized Temperature (T) > 50th Percentile Normalized Temperature (T)	Maximum Error E3	Maximum Error E4
1	F=0.0062-0.00348511*T+0.000222532*T^2+1.78892e-006*T^3	0.007	0.010	46.63	1	F=-1.3918+0.0592101*T-0.00044335*T^2+9.01314e-007*T^3	0.003	0.005
2	F=-5.6556853E-005+0.000915342*T-0.000168874*T^2+1.6419e-005*T^3	0.001	0.005	34.49	2	F=-4.4022+0.280921*T-0.00546897*T^2+4.70296e-005*T^3-1.5031e-007*T^4	0.005	0.004
3	F=0.0038-0.00115375*T+5.89654e-006*T^2+4.44099e-006*T^3	0.003	0.011	49.83	3	F=-2.1405+0.0836598*T-0.000709878*T^2+1.86971e-006*T^3	0.004	0.005
4	F=0.0010+0.0011688*T-0.000199589*T^2+7.47247e-006*T^3	0.003	0.005	50.30	4	F=-2.7537+0.105617*T-0.000953171*T^2+2.72067e-006*T^3	0.010	0.011
5	F=-0.0029+0.00477002*T-0.000424823*T^2+9.6577e-006*T^3	0.010	0.014	53.33	5	F=-5.4773+0.208222*T-0.00222757*T^2+7.92976e-006*T^3	0.005	0.001
6	F=0.0033-0.00131996*T+4.2921e-005*T^2+6.59473e-006*T^3	0.005	0.011	41.93	6	F=-1.8930+0.0910049*T-0.000951945*T^2+3.31049e-006*T^3	0.012	0.002
7	F=0.0027+0.000399691*T-0.000421155*T^2+3.31092e-005*T^3	0.005	0.014	29.76	7	F=-3.0128+0.216956*T-0.00436665*T^2+3.865e-005*T^3-1.26662e-007*T^4	0.006	0.002
8	F=0.0059-0.00342634*T+0.000251145*T^2+1.63051e-006*T^3	0.006	0.008	44.97	8	F=-1.8858+0.0841842*T-0.000810001*T^2+2.56546e-006*T^3	0.004	0.002
9	F=0.0045-0.0020666*T+7.94908e-005*T^2+4.62794e-006*T^3	0.005	0.012	45.51	9	F=-2.1772+0.095677*T-0.000954906*T^2+3.15716e-006*T^3	0.003	0.002
10	F=-0.0006+0.00088734*T-9.50822e-005*T^2+4.99791e-006*T^3	0.002	0.005	52.43	10	F=-1.6010+0.0547389*T-0.000272844*T^2-1.49371e-007*T^3	0.006	0.010
11	F=0.0061-0.0032791*T+0.000207057*T^2+1.02148e-006*T^3	0.007	0.008	50.80	11	F=-1.1423+0.039079*T-9.2176e-005*T^2-8.51089e-007*T^3	0.009	0.011
12	F=0.0045-0.00290531*T+0.000236687*T^2+4.93745e-006*T^3	0.004	0.008	38.04	12	F=-1.5543+0.0847607*T-0.000939301*T^2+3.47214e-006*T^3	0.002	0.002
13	F=0.0009+0.00115323*T-0.000174911*T^2+6.68484e-006*T^3	0.004	0.012	51.55	13	F=-2.2550+0.0820449*T-0.000624433*T^2+1.28924e-006*T^3	0.012	0.012
14	F=0.0022+0.000313842*T-0.000126646*T^2+7.56542e-006*T^3	0.006	0.011	46.67	14	F=-3.1303+0.133456*T-0.00143623*T^2+5.146e-006*T^3	0.009	0.002
15	F=0.0017-0.000235721*T-3.73449e-005*T^2+3.92325e-006*T^3	0.002	0.005	54.26	15	F=-2.6814+0.0935017*T-0.000734566*T^2+1.67355e-006*T^3	0.003	0.007
16	F=-0.0021+0.00720698*T-0.000909301*T^2+3.42974e-005*T^3-3.00747e-007*T^4	0.007	0.010	50.56	16	F=9.9898-0.572711*T+0.0122381*T^2-0.000109117*T^3+3.50164e-007*T^4	0.009	0.005
17	F=0.0047-0.00224082*T+0.000127342*T^2+2.79495e-006*T^3	0.005	0.008	48.28	17	F=-2.3026+0.0941702*T-0.000879148*T^2+2.67478e-006*T^3	0.004	0.003
18	F=0.0057-0.0030441*T+0.000141783*T^2+2.25433e-006*T^3	0.009	0.011	50.74	18	F=-1.2411+0.0447573*T-0.000189419*T^2-3.44913e-007*T^3	0.004	0.006
19	F=0.0016+0.00186134*T-0.00040401*T^2+1.92807e-005*T^3	0.005	0.014	37.37	19	F=-2.6077+0.138805*T-0.00175749*T^2+7.30566e-006*T^3	0.006	0.016
20	F=-0.0027+0.0023479*T-0.000206196*T^2+6.10404e-006*T^3	0.004	0.004	54.50	20	F=-4.6093+0.167437*T-0.00164333*T^2+5.29541e-006*T^3	0.009	0.009
21	F=0.0042-0.0019218*T+4.31604e-005*T^2+5.01862e-006*T^3	0.006	0.012	46.46	21	F=-2.0729+0.0893052*T-0.000856896*T^2+2.71031e-006*T^3	0.001	0.001
22	F=0.0064-0.00413995*T+0.000284622*T^2+5.50892e-006*T^3	0.007	0.011	36.74	22	F=-1.8466+0.10177*T-0.0012079*T^2+4.75024e-006*T^3	0.007	0.006
23	F=0.0013-0.000317206*T+8.81079e-006*T^2+3.10113e-006*T^3	0.004	0.004	54.10	23	F=-4.2978+0.157214*T-0.00153858*T^2+4.95757e-006*T^3	0.010	0.006
24	F=0.0041-0.00247502*T+0.000130657*T^2+3.32509e-006*T^3	0.003	0.011	46.58	24	F=-2.4992+0.106414*T-0.00107135*T^2+3.56927e-006*T^3	0.009	0.003
25	F=0.0086-0.00434009*T+0.000296385*T^2+1.68731e-006*T^3	0.009	0.013	43.28	25	F=-1.3767+0.0636302*T-0.000529214*T^2+1.30104e-006*T^3	0.013	0.011
26	F=-0.0005+0.00195531*T-0.00022761*T^2+7.55956e-006*T^3	0.003	0.006	50.88	26	F=-3.8553+0.15013*T-0.00153414*T^2+5.18087e-006*T^3	0.007	0.007
27	F=0.0089-0.00603744*T+0.000445323*T^2-7.83365e-007*T^3	0.012	0.013	43.03	27	F=-1.0393+0.0501528*T-0.000366333*T^2+6.82717e-007*T^3	0.006	0.006
28	F=0.0058-0.00378457*T+0.00029247*T^2+2.67082e-006*T^3	0.006	0.014	40.53	28	F=-1.5146+0.0769193*T-0.000780776*T^2+2.62864e-006*T^3	0.004	0.002
29	F=0.0002+0.000524113*T-9.00387e-005*T^2+4.69359e-006*T^3	0.000	0.003	53.92	29	F=-2.6548+0.093878*T-0.000753699*T^2+1.80081e-006*T^3	0.004	0.006
30	F=0.0083-0.00509165*T+0.000406511*T^2+1.03155e-006*T^3	0.009	0.013	39.67	30	F=-1.6509+0.0856562*T-0.000926625*T^2+3.35248e-006*T^3	0.003	0.001
31	F=0.0071-0.00596961*T+0.000699394*T^2+1.48227e-006*T^3	0.008	0.009	30.27	31	F=-2.0618+0.149731*T-0.00278821*T^2+2.32656e-005*T^3-7.29559e-008*T^4	0.006	0.003
32	F=0.0045-0.00232746*T+0.000117158*T^2+2.41965e-006*T^3	0.006	0.008	50.84	32	F=-1.1374+0.0197268*T+0.000724979*T^2-1.18751e-005*T^3+4.79018e-008*T^4	0.002	0.001
33	F=0.0030-0.00168168*T-5.39486e-005*T^2+6.43616e-006*T^3	0.012	0.014	48.13	33	F=-3.5892+0.148346*T-0.00159387*T^2+5.69194e-006*T^3	0.007	0.002

E1 = Maximum Prediction Error When Computed Frequency < 5%
E2 = Maximum Prediction Error When Computed Frequency Between 5 - 50%
E3 = Maximum Prediction Error When Computed Frequency Between 50 - 95%
E4 = Maximum Prediction Error When Computed Frequency >95%

Table 38. Percent Probability of Predicted Temperatures >2.0C at Each Frequency Level by Group

Month: May

GROUP	STANDARDIZED FREQUENCY LEVELS																			% OF ALL >
	0.001	0.005	0.01	0.03	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	0.95	0.97	0.99	0.995	0.999	2.0C
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	2.12	2.1
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
9	0	0	0	0	0	0	0	0	0	0	33	33	33	33	33	33	33	33	0	14.0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
14	0	0	0	0	0	0	0	0	0	0	25	25	25	25	25	25	25	25	0	10.5
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	10	10	1.6
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25	25	25	25	25	6.6
23	0	0	0	0	0	0	25	25	25	25	25	25	25	25	0	0	0	0	0	10.5
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	33	33	3.5
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
27	0	0	0	0	0	0	0	0	25	25	25	0	0	0	0	0	0	0	0	4.0
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
30	0	0	0	0	0	0	17	17	0	0	0	0	0	0	0	0	0	0	0	1.8
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	33	1.8
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0

Summer: June-July-August

Model performance was best in the summer season and provides a more parsimonious solution than in any other season. The number of groups was the fewest and averaged 27 for each of the summer months. About 84 percent of all the stations for the summer season contained no errors, and overall, about 96 percent of all generated levels were within the +/-2.0°C tolerance criterion. This corroborates the findings of Lackey (1964) and Spreen (1956), both of whom had the greatest predictive accuracy in their models during the warmer months. Summer finds the mean boundary between the warmer mT air masses and the cooler continental Polar air mass has risen into southern portions of Canada, although the cooler Polar air masses still occasionally impact the northern one-third of CONUS (Griffiths and Driscoll, 1982).

June -- Model performance in June was comparable to the performance during May. About 80 percent of the stations had no error and approximately 95 percent of all generated levels were within the tolerance criterion.

Figure 52 shows the June temperature frequency group patterns for North America and Figure 53 shows the same for the islands in the Pacific Ocean. June is comprised of 26 groups. The patterns in June are relatively similar to those of the preceding month. The groups covering the eastern one-half of the U.S. and Canadian Maritimes are showing an enhanced southwest-northeast axis, indicative of the strengthening of maritime Tropical (mT) air masses. The patterns in Canada maintain their northwest-southeast plunge into the Upper Great Plains. Coastal California is encompassed by Group 6 and the Pacific coastal areas north of about 45°N continue to show their characteristic banding pattern.

Groups 3 and 23 are of interest. Group 3 encompasses a portion of the southern Appalachian Mountains from the northernmost parts of Georgia through southeastern portions of Pennsylvania. Besides elevation, the obvious variable, Precipitation Effectiveness (P/E) is quite different between Group 3 and the groups that surround it (16 and 24). Group 23 is surrounded by Group 24 and is situated to the northeast of Lake Ontario and runs for about 300 miles in a southwest-to-northeast direction along the Saint Lawrence River. Group 23 has a higher P/E and lower monthly range than the much larger Group 24. This may, in fact, be due to its location, downwind of two of the Great Lakes, with prevailing southwesterly winds during the month. The Pacific islands are again divided into three groups with latitude and Precipitation Effectiveness (P/E) being the strongest discriminating variables.

Figures 54 and 55 show the group mean June skewness for North America and the Pacific islands, respectively. Approximately 70 percent of the Groups possess a positive skew. Areas of high positive skewness continue along the coastal Pacific areas of the continent and exhibit overall increased skewness when compared to May. The Canadian

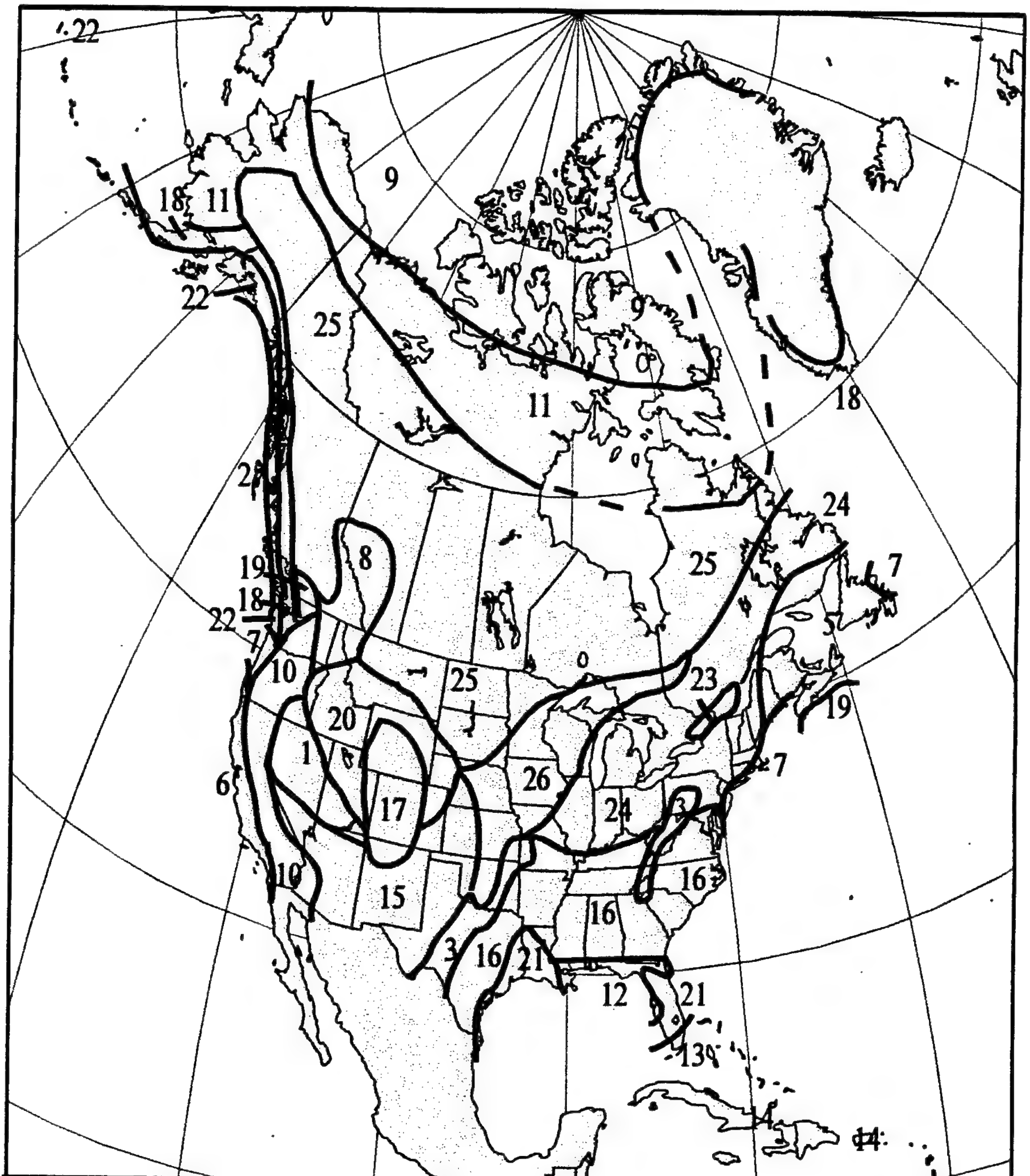

FIGURE 52. NORTH AMERICA TEMPERATURE FREQUENCY GROUPS FOR JUNE

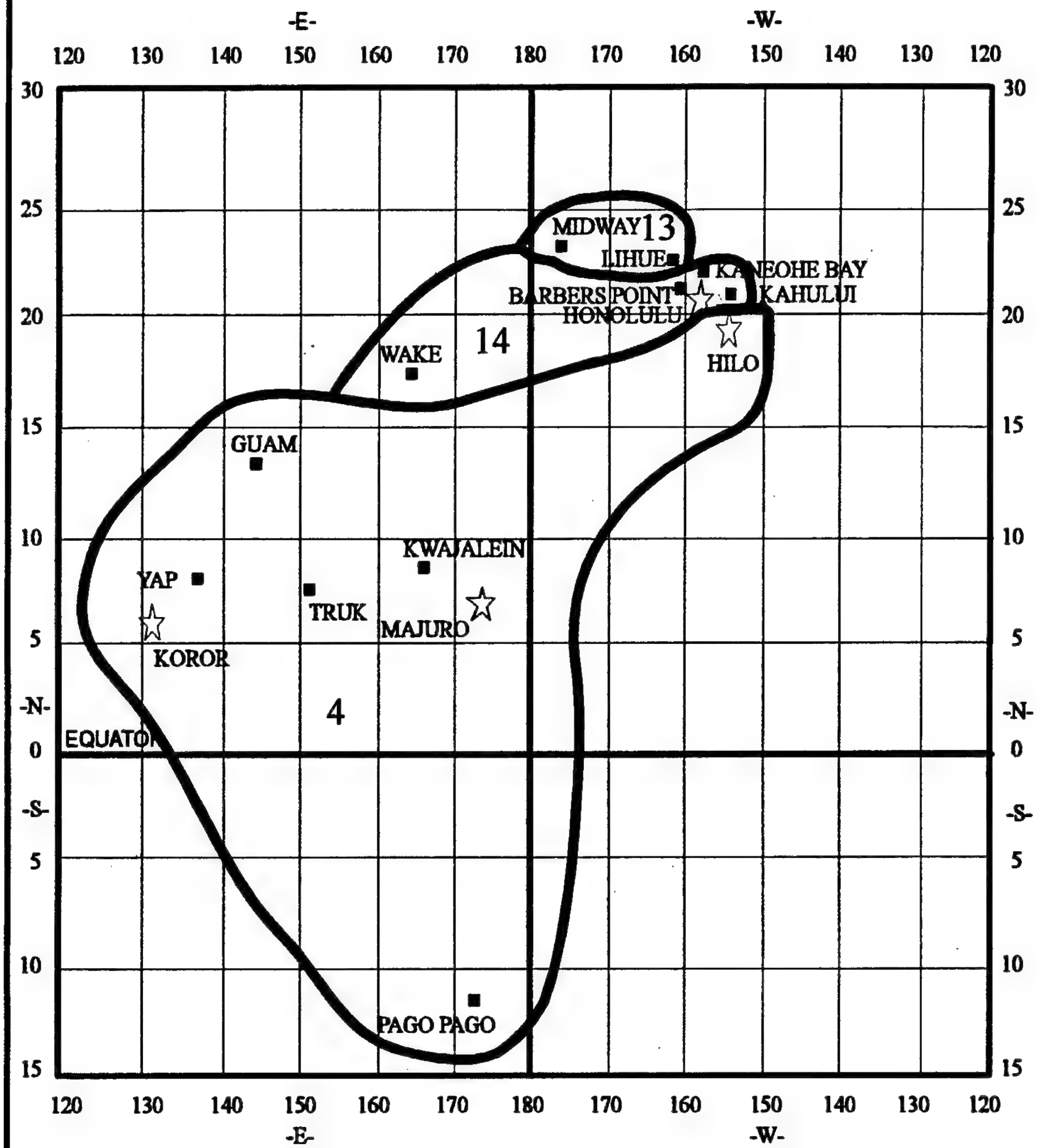

FIGURE 53. PACIFIC ISLANDS TEMPERATURE FREQUENCY GROUPS FOR JUNE

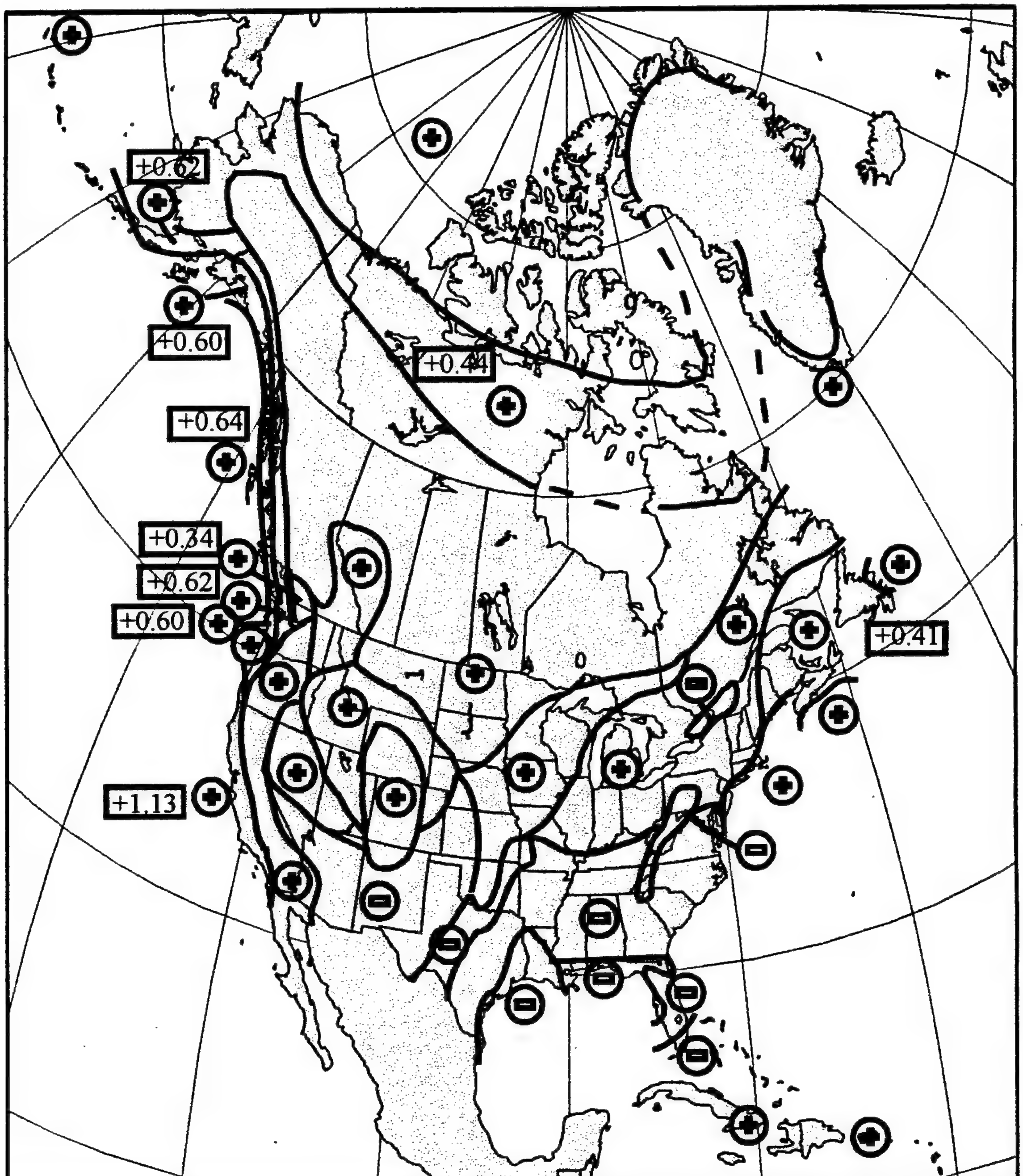

FIGURE 54. NORTH AMERICA TEMPERATURE FREQUENCY GROUP SKEWNESS FOR JUNE

⊕ = POSITIVE SKEW ⊖ = NEGATIVE SKEW

▭ = VALUES >/= 0.3 OR </= -0.3

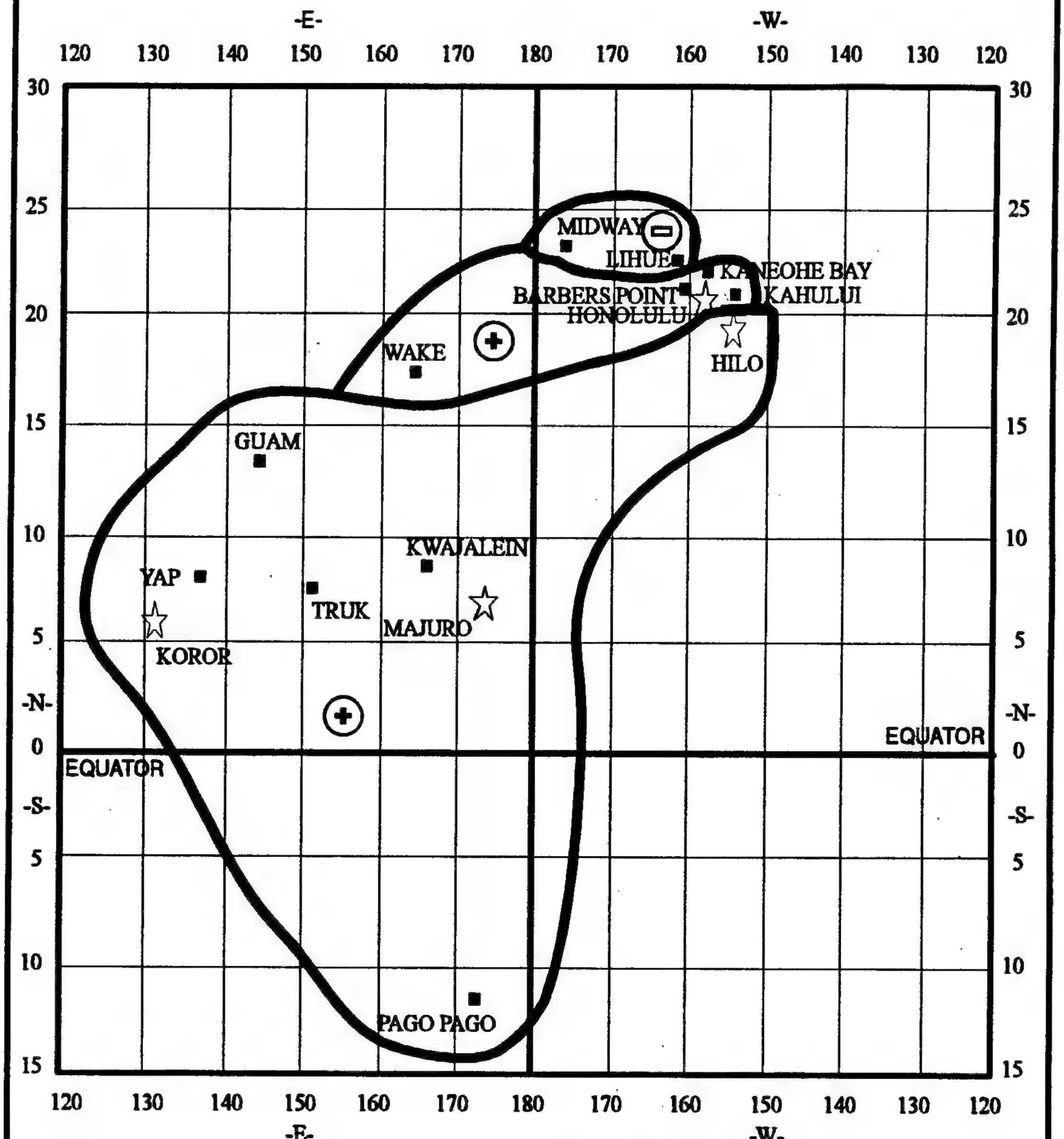

FIGURE 55. PACIFIC ISLANDS TEMPERATURE FREQUENCY GROUP SKEWNESS FOR JUNE

(+) = POSITIVE SKEW (−) = NEGATIVE SKEW

☐ = VALUES >/= 0.3 OR </= -0.3

Maritimes also continue to show a high positive skewness. Central Canada has made an abrupt change to high positive skewness, perhaps the result of almost continuous sunlight in the region. The High Arctic is remaining slightly positive (+0.05).

Negative skewness persists in the southerly one-third of CONUS. Skewness values, however, range from only -0.005 to -0.08 -- i.e., the distributions are fairly close to normal. Likewise, Groups 3 and 23, which were discussed earlier, also possess a slight negative skew to their distributions.

June group means for the attribute variables appear in Table 39, group mean normalized temperatures in Table 40, discriminant functions in Table 41, curve-fitting equations in Table 42, and percent probabilities by frequency level in Table 43.

July -- From June to July, there is a marked northward movement of most of the large circulation features affecting North America. The Pacific high moves northward and its mean axis is now at about 36°N and brings a fairly dry regime along the coastal Pacific from Alaska to California. The Azores-Bermuda high moves its mean axis to roughly 35°N and extends inland over the Carolinas (Ludlum, 1982). North of the central U.S., the mean boundary between the mT and cP are masses has migrated northward to over Hudson Bay (Bryson and Hare, 1974). Summer heat reaches its greatest intensity in July. About 72 percent of the States have experienced their high temperature extremes during July (Changery, 1995).

Figure 56 shows the July temperature frequency group patterns for North America and Figure 57 shows the same for the islands in the Pacific Ocean. July is comprised of 27 groups. The southeast portions of the U.S. again show a characteristic southwest-to-northeast trend and this banded pattern is similar to the continentality patterns of Figure 12. The western boundary of Groups 3 and 26 closely define the Cfa/Dfa and Bsk (steppe) boundary. Coastal California is divided into Groups 10 (northern portions) and Group 27 (southern portions). The P/E and monthly temperature range are the main variables causing this division. The P/E patterns of Figure 10 resemble the temperature frequency group patterns quite nicely. The U.S. Pacific Northwest again shows its complexity with three groups required to define a relatively small, but diverse, geographic area. The Pacific islands are composed of four groups, and besides latitude, P/E is another important discriminating variable.

Court's temperature frequency map (1951) for July (Figure 3) corresponds quite closely to the group patterns seen in Figure 56. The northern boundary of Court's Type I in the southeastern U.S. is approximated by the northern boundary of Group 9 and the western boundary of Group 25. The western boundary of Court's Type II has a similar location to the western boundary of Group 26.

Figures 58 and 59 show the group mean July skewness for North America and the

Table 39. Group Means for June

Group	Station Count	Latitude	Elevation	P/E	Continentality	Temperature Range Monthly	Temperature Range Daily	Normalized Mean Daily Max Team	Normalized Mean Daily Min Temp
1	4	40.16	4427	18.5	37.7	78.8	36.0	71.4	25.7
2	2	53.74	104	338.0	11.8	57.5	15.0	50.6	24.6
3	5	35.57	1597	74.3	39.2	61.0	22.8	73.1	35.7
4	5	10.70	62	147.9	-9.9	25.6	10.2	71.4	31.0
5	4	45.94	297	187.6	33.4	56.5	16.5	55.2	26.0
6	9	34.79	51	21.3	5.8	55.7	14.4	42.9	17.3
7	9	40.80	132	103.5	36.0	59.9	19.8	62.4	29.4
8	5	49.45	2888	43.1	35.4	64.0	24.4	63.1	25.0
9	3	73.16	440	45.7	38.9	51.0	7.0	57.2	43.2
10	7	37.90	633	19.8	33.1	71.4	31.3	68.9	25.0
11	5	64.28	111	45.1	40.9	55.8	13.4	51.8	27.9
12	8	30.04	50	85.3	28.2	52.1	18.3	77.2	42.1
13	5	25.44	33	61.7	8.0	31.4	11.6	75.2	38.4
14	5	20.57	34	32.5	-1.4	28.8	13.0	72.9	28.1
15	8	34.05	2914	16.1	42.3	66.3	28.8	73.5	30.1
16	26	35.06	435	84.3	37.8	59.2	21.3	72.3	36.4
17	6	39.45	5507	25.8	43.5	69.7	28.7	71.6	30.2
18	5	56.11	85	72.3	13.7	49.4	13.4	49.5	22.7
19	3	45.65	51	160.8	22.0	41.3	12.3	58.7	29.1
20	10	43.64	3596	31.8	45.3	73.4	27.4	65.3	27.9
21	12	29.58	76	68.8	28.6	46.5	18.6	75.3	35.3
22	2	55.88	90	155.5	9.5	47.0	12.0	51.7	26.5
23	2	45.40	246	114.9	50.3	58.5	18.0	66.6	35.8
24	28	41.54	603	94.2	43.7	64.7	21.9	67.2	33.4
25	7	52.11	1101	43.2	55.5	71.1	23.0	62.3	29.9
26	13	41.34	1091	62.9	52.7	66.6	23.0	66.1	31.6
ALL	198	39.32	985	72.6	34.1	58.8	20.7	66.4	31.3

Table 40. Group Mean Normalized Temperatures: June

	Frequency Levels																				
Group	0	0.001	0.005	0.01	0.03	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	0.95	0.97	0.99	0.995	0.999	1.0
1	0	6.06	10.69	13.75	19.06	22.05	27.05	33.71	39.27	44.21	49.13	54.61	60.55	66.93	74.10	78.89	81.95	86.80	88.82	92.54	100
2	0	3.58	8.35	11.12	16.68	19.31	23.11	27.24	30.08	32.61	34.87	37.17	39.85	43.34	48.79	54.58	59.14	69.87	75.52	84.25	100
3	0	7.04	14.03	18.30	24.70	28.01	33.04	39.12	43.32	46.91	50.76	55.09	60.14	65.44	71.78	76.15	78.80	83.76	86.32	90.60	100
4	0	10.24	17.15	19.49	24.32	27.39	31.34	36.88	40.71	43.71	46.70	49.85	54.35	59.15	64.70	68.72	71.43	74.64	76.39	82.53	100
5	0	3.82	7.69	9.84	14.36	16.47	20.28	25.04	29.06	32.64	36.83	41.15	46.14	51.85	59.16	66.54	71.23	79.46	82.94	91.21	100
6	0	3.55	6.96	8.53	11.55	12.96	15.34	18.17	20.51	22.63	24.97	27.68	30.83	34.62	40.01	45.10	49.17	57.97	64.86	80.84	100
7	0	4.82	10.42	12.99	18.25	21.14	25.62	31.33	35.47	39.37	43.07	47.07	51.70	57.28	64.73	70.80	74.35	80.68	84.07	89.89	100
8	0	3.31	7.77	10.40	15.94	18.92	23.04	28.71	33.46	37.85	42.34	47.08	52.21	58.19	66.97	73.83	77.69	84.10	86.69	92.16	100
9	0	7.20	15.84	20.57	25.73	29.33	34.28	38.83	41.96	44.87	47.83	50.78	54.34	58.85	65.52	70.58	73.44	80.20	83.85	90.26	100
10	0	5.69	10.36	12.74	17.41	20.21	24.77	30.84	35.58	40.25	45.07	50.10	55.74	61.87	69.60	75.28	78.50	83.91	86.25	90.79	100
11	0	4.90	9.02	12.06	16.34	18.58	22.22	26.88	30.58	33.91	37.11	40.75	44.92	50.37	57.86	64.96	69.43	77.77	82.36	90.43	100
12	0	15.52	25.19	29.11	34.87	37.42	41.23	45.67	49.12	52.19	55.53	59.50	63.95	68.38	73.72	77.75	80.01	84.20	86.50	91.04	100
13	0	11.78	19.10	22.11	27.90	30.58	35.06	40.32	44.22	47.50	50.83	54.68	58.90	63.91	69.66	73.37	76.27	80.82	83.33	88.39	100
14	0	6.19	12.16	15.08	20.19	23.24	26.97	32.34	36.16	40.02	44.35	49.21	54.37	59.44	65.72	70.15	73.21	77.22	80.77	84.65	100
15	0	5.82	12.26	15.33	20.86	23.99	29.01	35.59	40.78	45.69	50.55	55.55	60.99	66.81	73.58	78.46	81.54	86.19	88.51	92.78	100
16	0	8.84	15.73	19.19	25.47	28.85	33.99	39.75	43.11	47.28	51.03	55.40	60.19	65.47	71.82	76.33	79.07	83.87	86.36	91.17	100
17	0	6.37	12.65	15.71	21.18	24.17	28.84	34.97	39.85	44.47	49.16	54.12	59.52	65.70	73.40	78.62	81.52	86.06	88.28	92.62	100
18	0	6.17	7.14	9.06	12.74	14.77	18.26	22.55	26.03	29.28	37.81	38.04	40.00	44.41	50.76	57.83	62.91	72.31	76.73	85.87	100
19	0	4.70	9.93	12.21	17.29	20.07	23.97	29.16	33.22	36.78	40.28	43.70	47.65	51.59	57.54	63.10	67.52	74.37	77.93	85.93	100
20	0	4.28	10.76	13.81	18.81	21.48	25.79	31.31	35.72	39.88	44.19	48.84	54.01	60.05	68.03	74.04	77.59	83.85	86.73	91.47	100
21	0	8.70	16.25	19.89	26.35	29.49	33.66	38.40	41.97	45.41	49.32	54.33	59.81	65.06	71.01	75.19	77.72	82.16	84.52	89.28	100
22	0	2.60	6.59	8.47	13.55	16.63	21.31	26.02	29.42	32.43	35.26	38.08	41.39	45.42	50.55	55.23	58.98	67.00	72.28	87.97	100
23	0	5.82	14.30	17.15	21.59	25.48	31.21	37.78	42.86	47.28	49.94	53.80	58.40	63.61	71.48	77.63	80.13	85.45	88.93	94.29	100
24	0	7.33	12.87	15.89	21.45	24.51	29.64	36.24	41.13	45.35	49.25	53.20	57.62	62.87	69.69	74.73	77.62	82.58	85.03	90.04	100
25	0	7.00	11.53	14.57	20.22	22.80	27.25	33.03	37.30	41.10	42.28	48.68	53.10	58.27	65.22	70.99	74.37	81.02	84.47	90.32	100
26	0	5.91	11.36	14.29	19.87	22.88	27.94	34.33	38.95	43.13	47.18	51.34	55.93	61.14	67.92	73.22	76.35	81.97	84.87	90.66	100

Table 41. Discriminant Function Values: June

Function value = (a x lat) + (b x elev) + (c x P/E) + (d x K) + (e x mrange) + (f x drange) + (g x nmax) + (h x nmin) + constant

Group	a	b	c	d	e	f	g	h	constant
1	7.448	0.048	-0.268	1.505	16.906	-42.397	30.153	-23.366	-963.00
2	6.771	0.012	0.848	-0.366	19.603	-54.507	33.846	-27.460	-1000.10
3	6.509	0.025	-0.008	1.269	18.752	-51.098	33.977	-26.047	-929.64
4	3.949	0.008	0.375	-1.701	19.146	-58.498	37.435	-29.387	-888.84
5	6.631	0.015	0.364	0.963	19.110	-52.906	33.507	-27.169	-882.97
6	6.034	0.011	-0.129	-0.468	18.573	-51.166	31.922	-26.741	-706.98
7	6.554	0.013	0.094	1.084	18.906	-51.572	33.508	-26.604	-872.13
8	7.953	0.038	-0.172	1.254	19.146	-51.599	34.187	-27.602	-989.21
9	9.200	0.022	-0.156	1.124	20.288	-56.220	35.033	-26.850	-1105.11
10	6.770	0.015	-0.213	1.030	17.375	-44.636	31.183	-24.505	-841.85
11	8.567	0.017	-0.154	1.414	19.953	-54.723	34.586	-28.221	-996.26
12	5.759	0.011	0.078	0.446	18.716	-52.272	34.542	-25.672	-903.49
13	5.372	0.011	0.039	-0.698	18.737	-55.501	36.231	-27.535	-875.49
14	5.353	0.011	-0.052	-1.160	20.083	-60.396	39.311	-31.504	-945.62
15	6.775	0.036	-0.226	1.623	17.929	-47.653	32.698	-25.398	-931.58
16	6.241	0.015	0.042	1.118	18.644	-50.914	33.742	-25.773	-898.28
17	7.574	0.059	-0.231	1.817	18.728	-49.970	33.668	-26.367	-1096.63
18	7.716	0.014	-0.030	-0.124	19.016	-52.910	33.598	-27.556	-851.79
19	6.516	0.013	0.296	0.259	18.312	-52.388	33.485	-26.588	-829.30
20	7.615	0.043	-0.206	1.859	18.978	-49.917	33.194	-26.410	-1014.08
21	5.835	0.012	0.019	0.555	18.775	-53.296	35.382	-27.264	-890.81
22	7.382	0.014	0.252	-0.445	18.858	-52.979	33.449	-26.878	-862.05
23	6.925	0.016	0.117	1.840	19.325	-53.050	34.341	-26.773	-969.01
24	6.784	0.017	0.049	1.511	19.097	-51.464	33.743	-26.324	-934.04
25	7.954	0.024	-0.166	2.288	19.837	-52.540	34.279	-27.494	-1042.02
26	6.926	0.022	-0.065	2.109	18.987	-50.829	33.424	-26.368	-948.16

INPUT VARIABLES
lat = latitude
elev = elevation
P/E = Precipitation Effectiveness Index
K = Continentality
mrange = monthly temperature range
drange = daily temperature range
nmax = normalized mean daily maximum temperature
nmin = normalized mean daily minimum temperature

Table 42. Temperature Frequency Equations: June

Group	If Input Normalized Temperature (T) < 50th Percentile Normalized Temperature (T)	Maximum Error E1	Maximum Error E2	50th Percentile Normalized T	Group	If Input Normalized Temperature (T) > 50th Percentile Normalized Temperature (T)	Maximum Error E3	Maximum Error E4
1	F=0.0069-0.00384721*T+0.000274201*T^2+2.33215e-007*T^3	0.007	0.008	49.13	1	F=-0.5792+0.0201538*T+0.000112392*T^2-1.56578e-006*T^3	0.005	0.008
2	F=-0.0008+0.00248272*T-0.00040131*T^2+2.1408e-005*T^3	0.003	0.006	34.87	2	F=-4.8438+0.308229*T-0.00608621*T^2+5.3084e-005*T^3-1.72015e-007*T^4	0.002	0.004
3	F=0.0020+0.00018741*T-0.000102909*T^2+5.84533e-006*T^3	0.004	0.012	50.76	3	F=-1.9583+0.0724399*T-0.000523186*T^2+9.40767e-007*T^3	0.006	0.010
4	F=0.0004+0.0015869*T-0.000246058*T^2+9.49997e-006*T^3	0.001	0.006	46.70	4	F=-2.9379+0.12373*T-0.00127646*T^2+4.32762e-006*T^3	0.011	0.012
5	F=0.0094-0.00636091*T+0.000590583*T^2-1.29985e-006*T^3	0.010	0.014	36.83	5	F=-1.3043+0.0744865*T-0.000802094*T^2+2.87566e-006*T^3	0.009	0.002
6	F=0.0073-0.00646441*T+0.00054794*T^2+2.10161e-005*T^3	0.009	0.014	24.97	6	F=-1.7635+0.152405*T-0.00312316*T^2+2.80768e-005*T^3-9.32214e-008*T^4	0.006	0.002
7	F=0.0050-0.00252284*T+0.00014427*T^2+4.31732e-006*T^3	0.005	0.010	43.07	7	F=-1.9330+0.0903795*T-0.000923246*T^2+3.12587e-006*T^3	0.003	0.002
8	F=0.0085-0.00489501*T+0.000413277*T^2-4.42059e-007*T^3	0.009	0.009	42.34	8	F=-1.3839+0.0675397*T-0.00062678*T^2+1.89603e-006*T^3	0.004	0.002
9	F=-0.0032+0.00411453*T-0.000419844*T^2+1.16539e-005*T^3	0.008	0.013	47.83	9	F=-3.8506+0.161727*T-0.00179671*T^2+6.64582e-006*T^3	0.001	0.002
10	F=0.0078-0.00488301*T+0.000375384*T^2-4.482e-007*T^3	0.008	0.010	45.07	10	F=-1.1385+0.0507992*T-0.000346067*T^2+5.1497e-007*T^3	0.006	0.007
11	F=0.0060-0.00352985*T+0.000223545*T^2+6.39421e-006*T^3	0.008	0.009	37.11	11	F=-1.6225+0.0901901*T-0.0010355*T^2+3.96056E-006*T^3	0.001	0.004
12	F=-0.0002+0.00483746*T-0.000429789*T^2+9.17418e-006*T^3	0.009	0.014	55.53	12	F=-3.0858+0.103359*T-0.000796099*T^2+1.70494e-006*T^3	0.014	0.013
13	F=0.0009+0.0017563*T-0.000244802*T^2+8.01039e-006*T^3	0.004	0.009	50.83	13	F=-3.0902+0.1181*T-0.00110737*T^2+3.34984e-006*T^3	0.009	0.011
14	F=0.0079-0.00397018*T+0.000198272*T^2+3.37506e-006*T^3	0.009	0.015	44.35	14	F=-1.5906+0.0700235*T-0.000586102*T^2+1.44502e-006*T^3	0.016	0.014
15	F=0.0072-0.00370318*T+0.000221269*T^2+9.59151e-007*T^3	0.008	0.010	50.55	15	F=-1.1397+0.0402225*T-0.000122352*T^2-6.64982e-007*T^3	0.007	0.008
16	F=-0.0022+0.00489296*T-0.000578085*T^2+2.03492e-005*T^3-1.38702e-007*T^4	0.008	0.014	51.03	16	F=-2.1060+0.0778692*T-0.000589503*T^2+1.20879e-006*T^3	0.008	0.010
17	F=0.0075-0.00382641*T+0.000213446*T^2+1.4822e-006*T^3	0.008	0.012	49.16	17	F=-1.1420+0.0438047*T-0.000201703*T^2-2.2535e-007*T^3	0.004	0.006
18	F=0.0021-0.00100826*T-0.000163903*T^2+4.40938e-005*T^3-7.91424e-007*T^4	0.002	0.015	37.81	18	F=-6.9223+0.432574*T-0.00883131*T^2+7.94151e-005*T^3-2.64395e-007*T^4	0.019	0.011
19	F=0.0054-0.00295753*T+0.000178799*T^2+5.09381e-006*T^3	0.006	0.009	40.28	19	F=-2.5759+0.127106*T-0.00149913*T^2+5.85757e-006*T^3	0.010	0.004
20	F=0.0080-0.00448504*T+0.000286271*T^2+1.65059e-006*T^3	0.010	0.011	44.19	20	F=-1.4803+0.0678143*T-0.000595899*T^2+1.65464e-006*T^3	0.004	0.004
21	F=-0.0031+0.00730088*T-0.000869525*T^2+3.00539e-005*T^3-2.26239e-007*T^4	0.012	0.013	49.32	21	F=-1.2491+0.045163*T-0.000174028*T^2-5.33678e-007*T^3	0.015	0.017
22	F=0.0016-0.00015276*T-8.56266e-006*T^2+1.18946e-005*T^3	0.003	0.007	35.26	22	F=-2.1751+0.123273*T-0.00157287*T^2+6.58377e-006*T^3	0.012	0.013
23	F=1.31129991E-005+0.000256921*T-6.28815e-005*T^2+5.11181e-006*T^3	0.001	0.007	49.94	23	F=-2.5652+0.101689*T-0.000954659*T^2+2.94127e-006*T^3	0.003	0.003
24	F=0.0034-0.00156221*T+6.04254e-005*T^2+3.62661e-006*T^3	0.004	0.006	49.25	24	F=-2.5725+0.102388*T-0.000957001*T^2+2.90087e-006*T^3	0.004	0.006
25	F=-0.0016+0.00177145*T-0.000219868*T^2+1.05043e-005*T^3	0.003	0.019	42.28	25	F=2.3632-0.164178*T+0.00453775*T^2-4.74377e-005*T^3+1.71169e-007*T^4	0.013	0.008
26	F=0.0044-0.00211961*T+0.000113161*T^2+3.3513e-006*T^3	0.005	0.008	47.18	26	F=-2.3138+0.0965449*T-0.000919927*T^2+2.85495e-006*T^3	0.007	0.006

E1 = Maximum Prediction Error When Computed Frequency < 5%

E2 = Maximum Prediction Error When Computed Frequency Between 5 - 50%

E3 = Maximum Prediction Error When Computed Frequency Between 50 - 95%

E4 = Maximum Prediction Error When Computed Frequency >95%

Table 43. Percent Probability of Predicted Temperatures >2.0C at Each Frequency Level by Group

Month: June

GROUP	STANDARDIZED FREQUENCY LEVELS 0.001	0.005	0.01	0.03	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	0.95	0.97	0.99	0.995	0.999	% OF ALL > 2.0C
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
6	0	0	0	0	0	0	0	13	13	13	13	13	13	13	13	13	13	13	13	6.6
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	11	11	11	11	2.9
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
9	0	0	0	0	0	0	0	0	0	33	33	33	33	33	33	33	33	33	33	17.5
10	0	0	0	0	14	14	14	14	14	28	28	28	28	14	14	14	14	0	0	12.8
11	0	0	20	20	20	20	20	20	20	20	0	0	0	0	20	20	0	0	0	10.5
12	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.7
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
16	0	0	0	0	0	0	0	1.7	0	0	0	1.7	3.4	1.7	1.7	1.7	1.7	1.7	0	8.4
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
24	3.6	0	3.6	3.6	0	0	0	0	0	3.6	3.6	0	0	0	0	0	0	0	0	0.9
25	0	14.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.8
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0

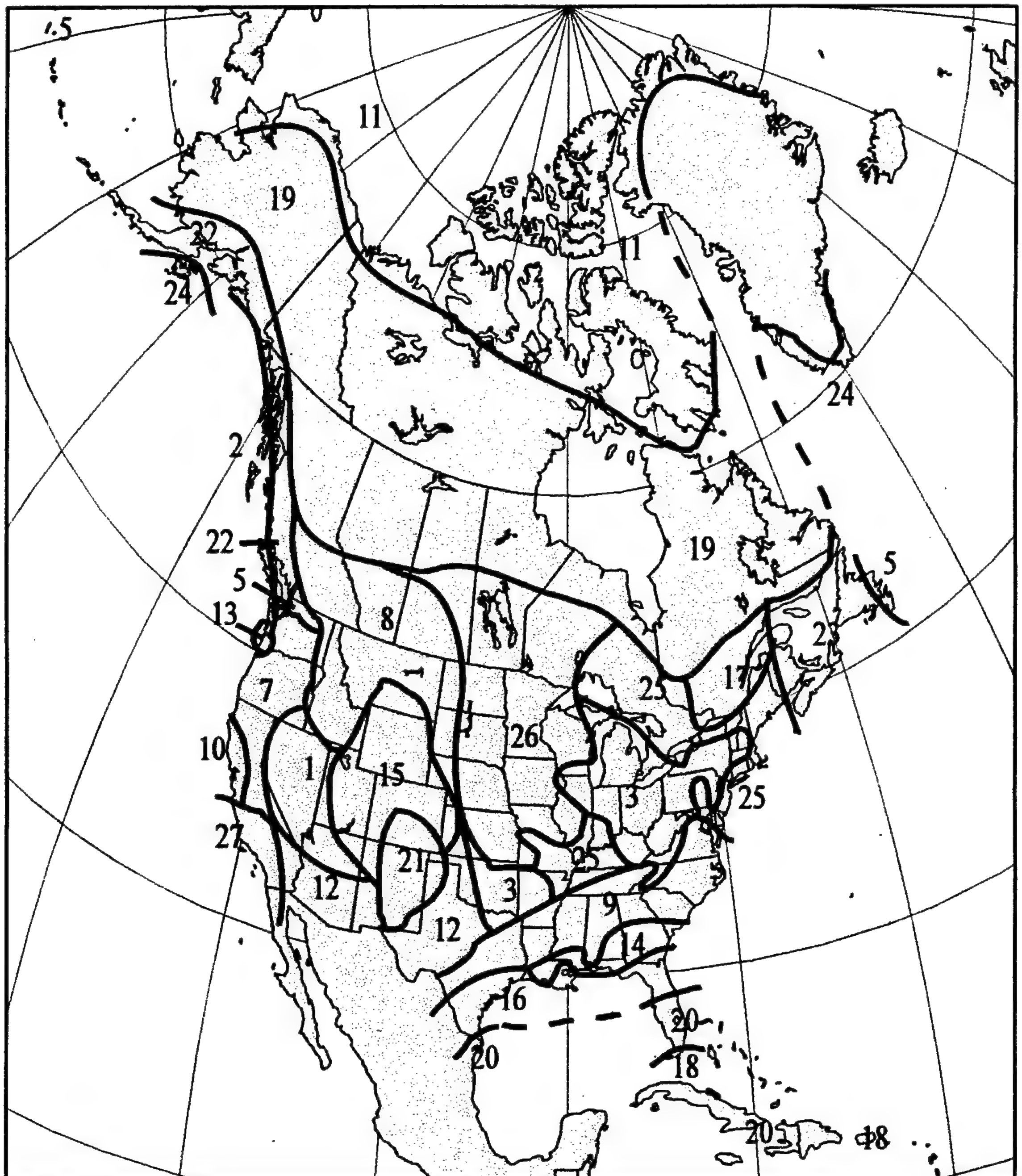

FIGURE 56. NORTH AMERICA TEMPERATURE FREQUENCY GROUPS FOR JULY

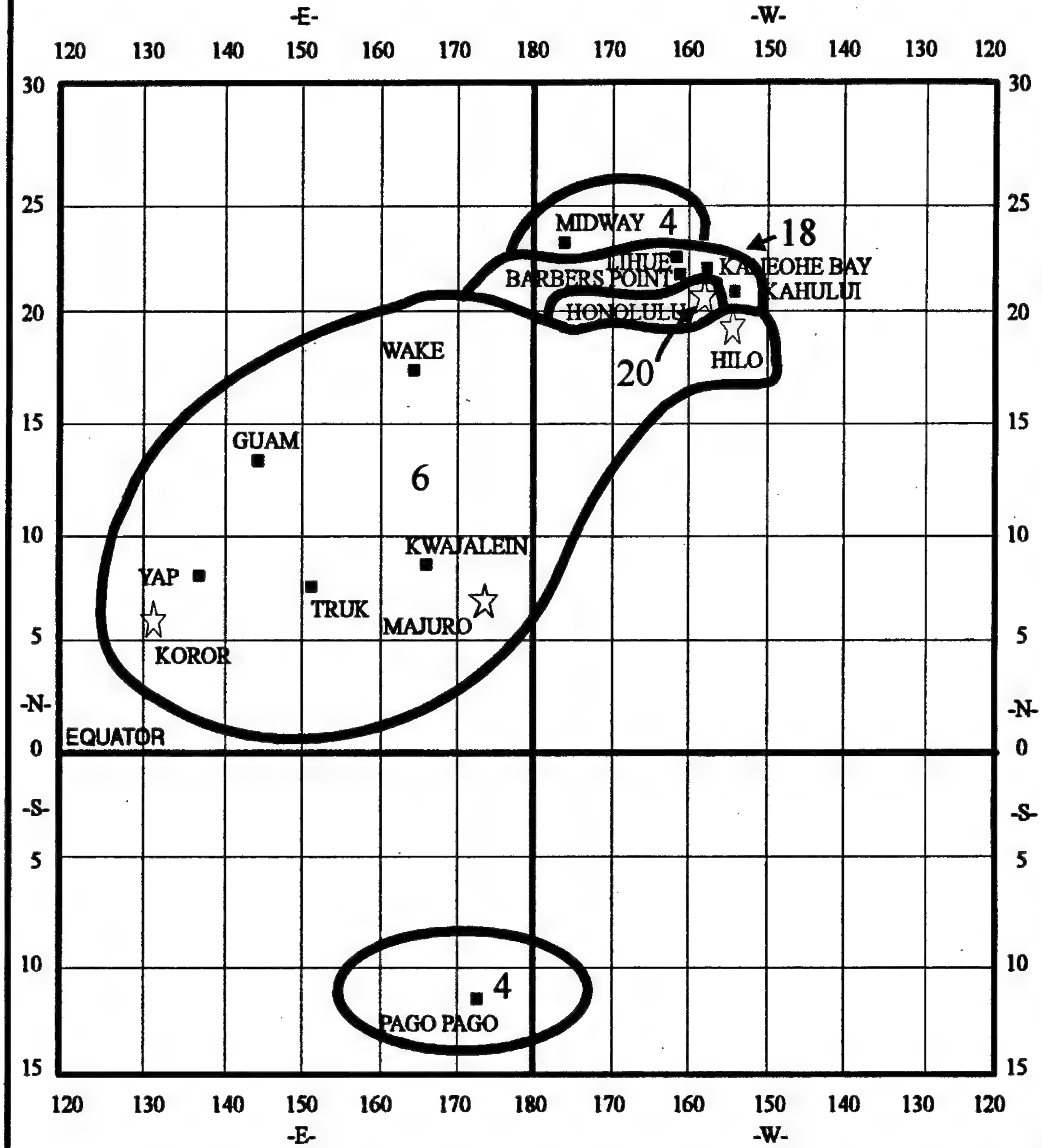

FIGURE 57. PACIFIC ISLANDS TEMPERATURE FREQUENCY GROUPS FOR JULY

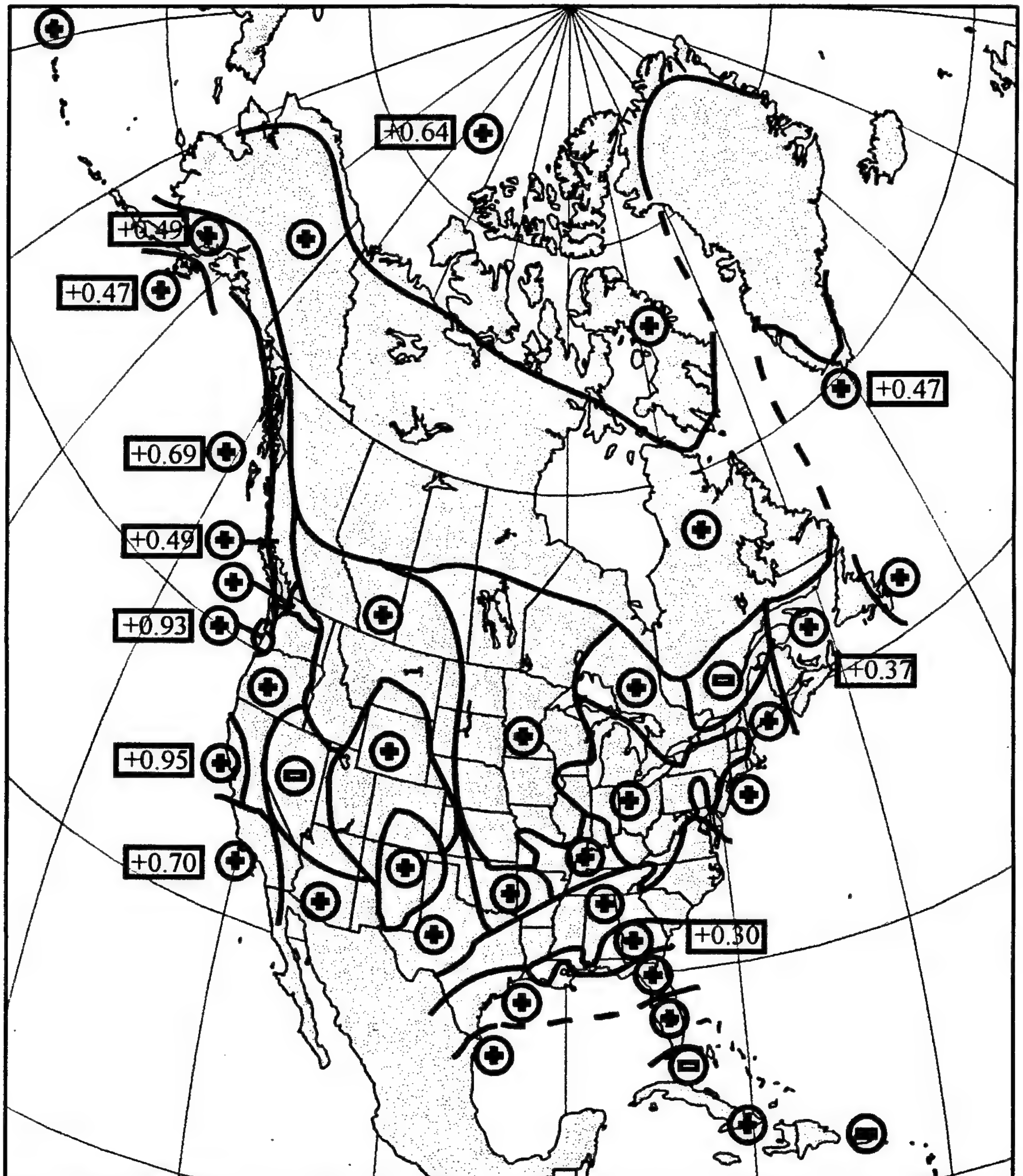

FIGURE 58. NORTH AMERICA TEMPERATURE FREQUENCY GROUP SKEWNESS FOR JULY

= POSITIVE SKEW = NEGATIVE SKEW
= VALUES >/= 0.3 OR </= -0.3

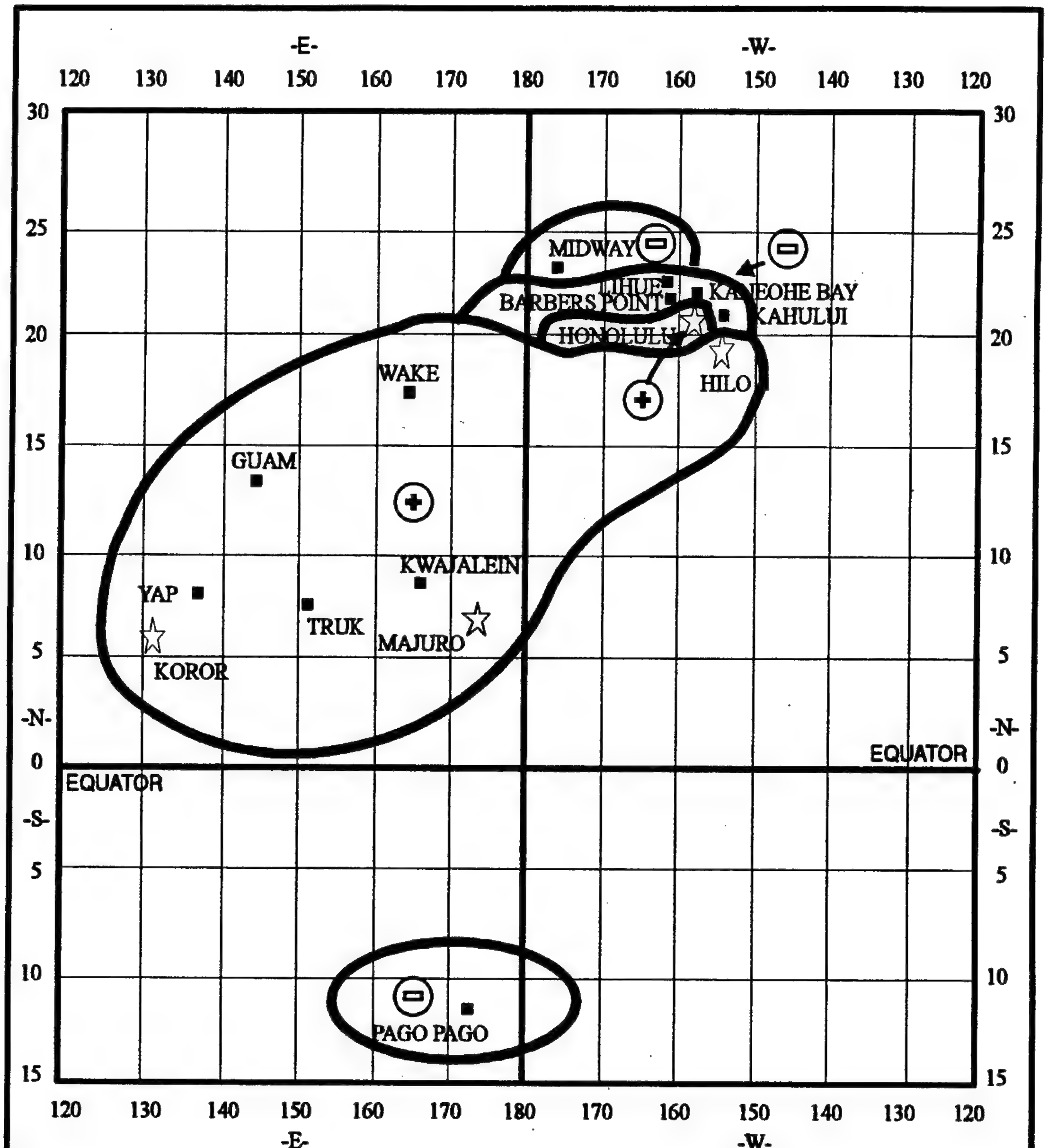

FIGURE 59. PACIFIC ISLANDS TEMPERATURE FREQUENCY GROUP SKEWNESS FOR JULY

(+) = POSITIVE SKEW (−) = NEGATIVE SKEW

☐ = VALUES >/= 0.3 OR </= -0.3

Pacific islands, respectively. Practically all (93 percent) of the groups are now positively skewed. The groups, in effect, are exhibiting a skewness in the direction of the prevailing high temperature extremes. Highest skewness is found along the entire Pacific Coast of North America and at several locations of the Atlantic Coast. Southern Greenland has high positive skew as well as the High Arctic.

The two areas of negative skewness are the extreme southern portion of Florida (Group 18) and the area extending from the eastern edge of Lake Ontario to the mouth of the Saint Lawrence River. This latter area also was negatively skewed in June.

July group means for the attribute variables appear in Table 44, group mean normalized temperatures in Table 45, discriminant functions in Table 46, curve-fitting equations in Table 47, and percent probabilities by frequency level in Table 48.

August -- Model performance in August was the best of any other month. Approximately 88 percent of all generated stations had no errors and about 97.5 percent of all generated levels met the ±2.0°C tolerance criterion.

During August, the Pacific high is at its greatest strength and expanse with its axis now centered at about 38°N latitude and its eastern portions reaching inland over British Columbia and the panhandle of Alaska. In the Atlantic Ocean, the center of the Azores-Bermuda high is at about 35°N latitude and extends over the coastal plain from Florida to Maryland. The average Pacific jet stream enters the continent in northern Washington State and remains in southern Canada until it exits the continent in Newfoundland (Ludlum, 1982; Bryson and Hare, 1974). General storms are infrequent in CONUS with the exception of the East Coast.

Figure 60 shows the August temperature frequency group patterns for North America and Figure 61 shows the same for the islands in the Pacific Ocean. August is comprised of 28 groups. The overall patterns for August are, in many ways, similar to the other two summer months. The eastern half of CONUS is comprised of only a few geographically large groups. This may be the result of the general lack of storminess in this region during August to which was just alluded. The groups in the Rocky Mountain region look quite similar to the June and July groupings. Coastal California is again represented by a single group (7), but now the Channel Islands off the coast from Los Angeles form their own group (21). A much smaller P/E Index value and a smaller monthly range are the important variables contributing to the differences between these two groups. The Pacific islands are divided into three groups, with P/E being an important variable.

Figures 62 and 63 show the group mean August skewness for North America and

Table 44. Group Means for July

Group	Station Count	Latitude	Elevation	P/E	Continentality	Temperature Range Monthly	Temperature Range Daily	Normalized Mean Daily Max Team	Normalized Mean Daily Min Temp
1	4	40.16	4427	18.5	37.7	73.3	40.3	80.5	25.5
2	2	53.74	104	338.0	11.8	54.0	15.0	49.9	22.6
3	25	40.60	791	89.4	43.1	58.4	21.7	69.8	32.7
4	2	21.27	20	107.6	0.2	26.5	8.0	74.0	43.6
5	3	48.58	320	163.3	24.8	54.0	15.7	63.5	34.4
6	4	9.79	75	145.1	-10.6	23.5	11.0	71.4	24.5
7	5	41.74	563	44.6	27.3	69.4	34.6	71.2	21.2
8	9	46.32	2698	36.5	45.0	70.8	29.3	68.4	26.9
9	23	34.31	358	83.7	36.5	50.8	19.5	70.6	32.3
10	4	36.66	32	28.6	7.5	57.5	17.5	48.2	17.8
11	5	71.95	286	38.6	40.2	44.0	9.4	45.4	24.3
12	10	34.01	1944	15.0	40.9	58.9	26.3	74.1	29.2
13	1	46.15	8	177.7	7.6	61.0	16.0	47.5	21.3
14	6	30.73	144	83.0	32.3	43.3	18.2	68.1	26.2
15	10	42.02	4536	29.6	44.1	64.1	30.1	75.1	28.0
16	11	29.58	41	70.4	29.0	41.9	18.2	73.5	30.0
17	2	45.40	246	114.9	50.3	54.0	18.0	72.2	38.7
18	6	21.58	37	39.9	0.6	28.0	11.8	77.1	35.0
19	6	60.37	599	48.4	44.4	54.3	18.3	61.2	27.1
20	6	25.89	35	61.2	13.5	31.8	15.7	74.1	24.9
21	5	38.01	4512	21.9	40.2	53.6	25.8	70.6	22.3
22	3	51.89	52	58.6	14.7	49.7	16.3	57.6	24.8
23	5	44.78	175	175.1	31.7	47.2	14.6	57.9	27.1
24	3	63.50	147	106.4	12.0	40.7	10.0	49.2	24.6
25	17	41.35	392	102.6	42.8	55.1	20.2	66.0	29.2
26	16	41.83	1099	61.7	52.9	64.1	22.7	67.2	31.7
27	5	33.30	67	15.5	4.5	41.6	11.2	52.0	25.0
ALL	198	39.32	985	72.6	34.1	53.1	20.6	67.7	29.0

Table 45. Group Mean Normalized Temperatures: July

Group	Frequency Levels																				
	0	0.001	0.005	0.01	0.03	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	0.95	0.97	0.99	0.995	0.999	1.0
1	0	8.70	13.93	16.63	21.82	24.96	30.74	38.57	44.34	49.88	56.31	63.08	68.50	73.48	79.22	82.89	84.82	88.40	90.20	93.39	100
2	0	4.35	8.71	11.25	16.03	18.93	22.76	26.43	29.09	31.35	33.64	36.14	39.18	42.99	48.67	54.67	60.11	70.78	77.44	87.90	100
3	0	7.40	13.20	16.31	22.28	25.60	30.74	37.00	41.43	45.29	49.16	53.34	57.95	63.14	69.61	74.39	77.30	82.48	85.37	91.25	100
4	0	15.81	23.06	26.37	33.32	36.77	42.22	47.40	50.80	53.85	56.49	59.33	62.25	66.77	72.66	76.85	79.36	83.79	86.66	88.96	100
5	0	8.27	14.70	17.58	22.09	24.13	28.17	34.11	38.99	43.29	47.17	50.42	53.69	58.89	66.37	72.04	75.65	81.74	84.39	89.94	100
6	0	9.59	16.25	18.41	21.77	24.53	28.71	33.87	37.87	41.31	44.74	48.62	53.69	59.33	65.38	70.07	72.64	76.09	78.08	84.18	100
7	0	5.65	9.60	11.67	15.86	18.43	22.81	28.46	33.13	37.88	43.35	49.35	55.60	62.47	70.42	75.87	79.26	84.37	86.87	91.37	100
8	0	6.01	11.61	14.17	18.77	21.45	25.87	31.80	36.49	40.94	45.50	50.40	55.75	61.66	69.14	74.44	77.48	82.48	84.94	90.36	100
9	0	9.09	15.64	18.87	24.46	27.06	30.78	35.05	38.41	41.84	45.79	50.62	56.11	61.90	68.55	73.36	76.31	81.59	84.35	89.49	100
10	0	4.09	7.54	9.60	11.88	13.42	15.62	18.64	20.98	23.47	26.30	29.71	33.85	38.34	44.25	49.57	53.45	61.85	67.26	77.99	100
11	0	2.77	5.67	7.46	8.71	11.40	14.69	18.93	22.39	25.90	29.74	34.22	38.65	43.68	51.57	59.14	63.91	71.67	76.26	84.13	100
12	0	10.21	15.48	18.01	22.67	25.24	29.43	35.15	39.88	44.50	49.46	54.80	60.35	66.25	72.78	77.17	79.61	83.76	85.80	90.16	100
13	0	6.27	9.14	11.15	16.03	18.50	21.87	25.00	27.21	29.14	31.23	33.48	36.26	39.52	43.92	48.19	51.61	60.63	66.29	79.23	100
14	0	7.29	13.39	15.76	19.57	21.68	24.47	28.28	31.46	34.85	39.01	44.34	50.62	56.92	64.00	69.03	72.03	77.28	80.01	86.05	100
15	0	7.23	13.42	16.09	21.25	24.08	28.49	34.40	39.20	43.84	48.74	53.99	59.82	66.30	73.80	78.67	81.26	85.51	87.73	91.96	100
16	0	9.78	17.59	20.16	23.90	25.87	28.76	32.81	36.45	40.06	44.21	50.08	56.18	61.78	68.14	72.45	74.98	79.61	82.11	87.17	100
17	0	6.70	14.32	18.22	25.34	28.92	34.84	40.29	43.92	48.15	52.20	56.44	60.76	66.31	73.16	76.64	79.95	85.71	89.55	93.51	100
18	0	11.34	18.16	21.43	27.91	30.31	35.24	39.43	43.16	46.40	49.89	54.01	58.98	63.96	69.64	74.23	76.60	81.31	83.66	88.00	100
19	0	5.55	10.82	13.47	17.91	20.09	23.85	29.03	32.97	36.87	41.08	45.48	49.92	56.13	64.86	71.21	75.05	81.09	84.51	91.06	100
20	0	8.46	12.13	14.19	17.69	19.62	23.13	27.82	32.00	36.20	41.07	47.07	54.33	60.79	67.77	72.43	74.86	79.73	82.53	87.88	100
21	0	4.47	8.80	11.10	14.98	17.31	21.35	27.05	32.07	37.14	42.28	47.89	54.13	61.02	69.27	74.76	77.68	82.68	85.42	91.56	100
22	0	6.49	11.48	13.43	17.45	19.78	23.13	27.15	30.30	33.56	36.99	40.47	43.99	49.13	56.72	63.67	68.48	77.45	81.29	89.10	100
23	0	8.50	11.19	13.36	17.89	20.58	24.27	29.33	33.05	36.29	39.30	42.11	45.57	50.66	57.84	63.57	66.95	72.10	75.40	82.43	100
24	0	5.37	8.67	10.82	15.34	17.84	22.01	27.23	31.16	34.61	37.83	40.63	43.29	47.55	54.75	61.69	66.44	76.01	80.86	87.53	100
25	0	5.07	10.36	13.13	18.72	21.87	26.86	33.12	37.49	41.38	45.22	49.37	53.88	59.14	65.93	71.17	74.43	80.58	83.79	89.31	100
26	0	7.69	13.03	16.08	21.76	24.86	29.56	35.38	39.68	43.60	47.53	51.77	56.32	61.42	68.10	72.98	76.15	81.57	84.47	89.89	100
27	0	6.92	10.42	12.48	15.86	17.87	20.77	24.66	27.67	30.62	33.56	36.65	40.13	44.27	49.92	54.86	58.31	65.07	69.04	79.40	100

Table 46. Discriminant Function Values: July

Function value = (a x lat) + (b x elev) + (c x P/E) + (d x K) + (e x mrange) + (f x drange) + (g x nmax) + (h x nmin) + constant

Group	a	b	c	d	e	f	g	h	constant
1	9.191	0.022	-0.323	-1.517	34.461	-84.351	51.202	-44.257	-1265.83
2	10.741	0.008	0.493	-1.771	40.071	-103.878	58.870	-54.115	-1525.13
3	9.380	0.010	-0.216	-0.999	40.522	-105.518	60.484	-53.322	-1445.33
4	7.355	0.006	-0.266	-2.717	35.927	-98.276	56.663	-46.687	-1229.89
5	10.442	0.010	-0.075	-1.829	41.474	-108.797	61.700	-54.397	-1519.78
6	7.267	0.003	-0.158	-2.874	42.765	-116.839	66.994	-58.940	-1571.53
7	9.375	0.006	-0.270	-1.829	37.204	-92.476	55.172	-49.077	-1304.55
8	10.168	0.018	-0.352	-1.164	40.456	-102.523	59.000	-52.592	-1469.76
9	8.729	0.007	-0.236	-1.177	39.906	-105.050	60.339	-52.925	-1389.47
10	9.498	0.008	-0.460	-2.550	42.276	-109.149	60.980	-55.631	-1396.92
11	12.720	0.014	-0.418	-1.253	40.994	-109.438	60.309	-54.898	-1520.26
12	8.881	0.013	-0.418	-1.217	39.848	-103.119	59.687	-52.367	-1402.38
13	10.444	0.008	-0.038	-2.393	43.167	-111.216	62.110	-56.956	-1527.26
14	8.471	0.005	-0.222	-1.171	40.104	-106.622	61.199	-54.396	-1378.24
15	9.896	0.025	-0.374	-1.202	39.397	-100.778	58.470	-51.353	-1457.53
16	8.522	0.005	-0.290	-1.482	40.697	-108.640	62.641	-54.904	-1441.56
17	9.768	0.009	-0.157	-0.698	40.840	-107.833	61.605	-53.805	-1515.81
18	8.293	0.006	-0.495	-2.963	41.599	-113.465	65.210	-55.589	-1532.78
19	11.812	0.012	-0.376	-1.196	43.007	-113.122	63.818	-57.449	-1633.08
20	8.858	0.005	-0.374	-2.204	43.721	-118.451	68.029	-60.126	-1629.62
21	9.763	0.025	-0.408	-1.184	40.859	-106.658	61.139	-54.567	-1486.06
22	11.122	0.009	-0.391	-2.464	42.038	-110.381	62.428	-55.837	-1511.58
23	9.664	0.008	0.038	-1.086	39.408	-104.102	58.971	-53.030	-1365.78
24	12.093	0.011	-0.258	-2.435	40.186	-106.941	59.826	-53.715	-1454.23
25	9.380	0.008	-0.160	-0.857	40.290	-105.343	60.211	-53.679	-1416.64
26	9.470	0.012	-0.285	-0.600	41.336	-106.995	60.823	-54.127	-1479.15
27	8.876	0.008	-0.513	-2.619	39.165	-103.798	58.061	-51.366	-1241.37

INPUT VARIABLES
lat = latitude
elev = elevation
P/E = Precipitation Effectiveness Index
K = Continentality
mrange = monthly temperature range
drange = daily temperature range
nmax = normalized mean daily maximum temperature
nmin = normalized mean daily minimum temperature

Table 47. Temperature Frequency Equations: July

Group	If Input Normalized Temperature (T) < 50th Percentile Normalized Temperature (T)	Maximum Error E1	Maximum Error E2	50th Percentile Normalized T	Group	If Input Normalized Temperature (T) > 50th Percentile Normalized Temperature (T)	Maximum Error E3	Maximum Error E4
1	F=0.0072-0.00416047*T+0.000257768*T^2-4.4545e-007*T^3	0.007	0.014	56.31	1	F=1.9393-0.0931906*T+0.00166575*T^2-8.28713e-006*T^3	0.009	0.009
2	F=-0.0012+0.00310975*T-0.00050183*T^2+2.55512e-005*T^3	0.005	0.010	33.64	2	F=-3.7175+0.241419*T-0.00463357*T^2+3.93548e-005*T^3-1.24439e-007*T^4	0.002	0.003
3	F=0.0030-0.000733773*T-2.93897e-005*T^2+5.22116e-006*T^3	0.004	0.010	49.16	3	F=-2.2754+0.0899805*T-0.000789547*T^2+2.16776e-006*T^3	0.009	0.009
4	F=-0.0027+0.00621016*T-0.000469391*T^2+9.13538e-006*T^3	0.013	0.010	56.49	4	F=-6.4387+0.234128*T-0.00245387*T^2+8.56458e-006*T^3	0.003	0.002
5	F=0.0068-0.00429084*T+0.000241982*T^2+1.17268e-006*T^3	0.011	0.006	47.17	5	F=-3.2798+0.13478*T-0.00141607*T^2+4.96289e-006*T^3	0.009	0.001
6	F=0.0034-0.00175785*T-9.40406e-007*T^2+6.55487e-006*T^3	0.008	0.009	44.74	6	F=-1.8189+0.07987*T-0.00071887*T^2+2.01774e-006*T^3	0.010	0.006
7	F=0.0096-0.00659544*T+0.00056862*T^2-3.46627e-006*T^3	0.011	0.012	43.35	7	F=-0.5124+0.0260818*T-3.11796e-005*T^2-7.89603e-007*T^3	0.007	0.009
8	F=0.0076-0.00465948*T+0.000315755*T^2+6.43751e-007*T^3	0.007	0.010	45.50	8	F=-1.3089+0.0569634*T-0.000415801*T^2+7.66001e-007*T^3	0.007	0.009
9	F=0.0048-0.00115497*T-7.8278e-005*T^2+6.86156e-006*T^3	0.008	0.018	45.79	9	F=-2.1989+0.0898432*T-0.000811452*T^2+2.32492e-006*T^3	0.009	0.009
10	F=-0.0018+0.0105416*T-0.00291848*T^2+0.000241843*T^3-4.5032e-006*T^4	0.006	0.004	26.30	10	F=-0.8981+0.0768292*T-0.0010177*T^2+4.39386e-006*T^3	0.016	0.011
11	F=0.0070-0.00761893*T+0.00118132*T^2-1.21275e-005*T^3	0.007	0.011	29.74	11	F=-0.8847+0.0673601*T-0.000800515*T^2+3.15462e-006*T^3	0.009	0.004
12	F=0.0072-0.00496719*T+0.00026373*T^2+8.86685e-007*T^3	0.015	0.015	49.46	12	F=-0.7536+0.0252271*T+7.5805e-005*T^2-1.53305e-006*T^3	0.009	0.011
13	F=-0.0010+0.00474056*T-0.000798201*T^2+3.74783e-005*T^3	0.005	0.013	31.23	13	F=-3.9596+0.273857*T-0.00561353*T^2+5.04865e-005*T^3-1.67772e-007*T^4	0.007	0.001
14	F=-0.0024+0.0117853*T-0.00200152*T^2+9.93853e-005*T^3-1.21259e-006*T^4	0.010	0.007	39.01	14	F=1.4032-0.0966097*T+0.00295648*T^2-3.2043e-005*T^3+1.17358e-007*T^4	0.007	0.002
15	F=0.0083-0.00463861*T+0.000265338*T^2+8.64601e-007*T^3	0.011	0.013	48.74	15	F=-0.6741+0.0248061*T+4.68424e-005*T^2-1.27939e-006*T^3	0.005	0.009
16	F=-0.0016+0.0132491*T-0.00190644*T^2+7.97227e-005*T^3-8.44424e-007*T^4	0.011	0.006	44.21	16	F=3.6098-0.226934*T+0.00559131*T^2-5.44256e-005*T^3+1.85956e-007*T^4	0.008	0.002
17	F=0.0027+6.57444e-005*T-9.61024e-005*T^2+5.41732e-006*T^3	0.005	0.019	52.20	17	F=-2.5060+0.0917284*T-0.0007536*T^2+1.86311e-006*T^3	0.013	0.007
18	F=0.0014+0.00191506*T-0.000271813*T^2+8.81791e-006*T^3	0.005	0.017	49.89	18	F=-2.2876+0.0874513*T-0.0007254*T^2+1.79201e-006*T^3	0.010	0.012
19	F=0.0089-0.00562157*T+0.000385274*T^2+1.22325e-006*T^3	0.011	0.013	41.08	19	F=-1.5308+0.0767785*T-0.00077302*T^2+2.58245e-006*T^3	0.005	0.001
20	F=-6.29174888E-005+0.00498364*T-1.01004e-003*T^2+6.03865e-005*T^3-7.67953e-007*T^4	0.001	0.002	41.07	20	F=2.4189-0.151613*T+0.00392811*T^2-3.88533e-005*T^3+1.33135e-007*T^4	0.005	0.006
21	F=0.0090-0.00670491*T+0.000633113*T^2-4.65418e-006*T^3	0.009	0.009	42.28	21	F=-0.6072+0.0318521*T-0.000119491*T^2-3.88631e-007*T^3	0.006	0.010
22	F=-0.0019+0.0082362*T-0.00148511*T^2+8.04718e-005*T^3-9.83097e-007*T^4	0.008	0.005	36.99	22	F=-1.7987+0.0995007*T-0.00117916*T^2+4.64406e-006*T^3	0.008	0.008
23	F=0.0027-0.00155793*T+1.74598e-005*T^2+8.3547e-006*T^3	0.004	0.007	39.30	23	F=-2.4100+0.121261*T-0.00143336*T^2+5.61908e-006*T^3	0.012	0.005
24	F=0.0038-0.00249848*T+0.000196226*T^2+5.84277e-006*T^3	0.004	0.006	37.83	24	F=-4.8512+0.288988*T-0.00540595*T^2+4.51192e-005*T^3-1.4108e-007*T^4	0.008	0.003
25	F=0.0050-0.00202656*T+6.78886e-005*T^2+5.0873e-006*T^3	0.006	0.013	45.22	25	F=-1.7594+0.0773697*T-0.000696159*T^2+1.97924e-006*T^3	0.010	0.008
26	F=0.0043-0.00167554*T+3.86857e-005*T^2+4.64728e-006*T^3	0.005	0.011	47.53	26	F=-2.3589+0.0972516*T-0.000917632*T^2+2.80612e-006*T^3	0.008	0.007
27	F=0.0055-0.00445636*T+0.000251322*T^2+9.90736e-006*T^3	0.010	0.015	33.56	27	F=-1.8572+0.111406*T-0.00142787*T^2+5.99694e-006*T^3	0.008	0.008

E1 = Maximum Prediction Error When Computed Frequency < 5%
E2 = Maximum Prediction Error When Computed Frequency Between 5 - 50%
E3 = Maximum Prediction Error When Computed Frequency Between 50 - 95%
E4 = Maximum Prediction Error When Computed Frequency >95%

Table 48. Percent Probability of Predicted Temperatures >2.0C at Each Frequency Level by Group

Month: July

	STANDARDIZED FREQUENCY LEVELS																			% OF ALL >
GROUP	0.001	0.005	0.01	0.03	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	0.95	0.97	0.99	0.995	0.999	2.0C
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
7	0	0	0	20	20	20	20	20	20	20	40	40	20	20	0	0	0	0	0	13.7
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
11	0	0	0	0	0	0	0	0	0	20	20	20	20	0	0	0	0	0	20	5.3
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
19	0	17	17	17	17	17	17	17	0	0	0	0	0	0	0	0	0	0	0	6.1
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	20	20	20	4.2
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
25	0	0	6	0	0	0	0	6	6	6	6	6	6	6	6	6	6	6	6	4.3
26	0	0	0	0	0	0	0	6	6	6	6	6	6	12	12	18	18	18	6	6.6
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0

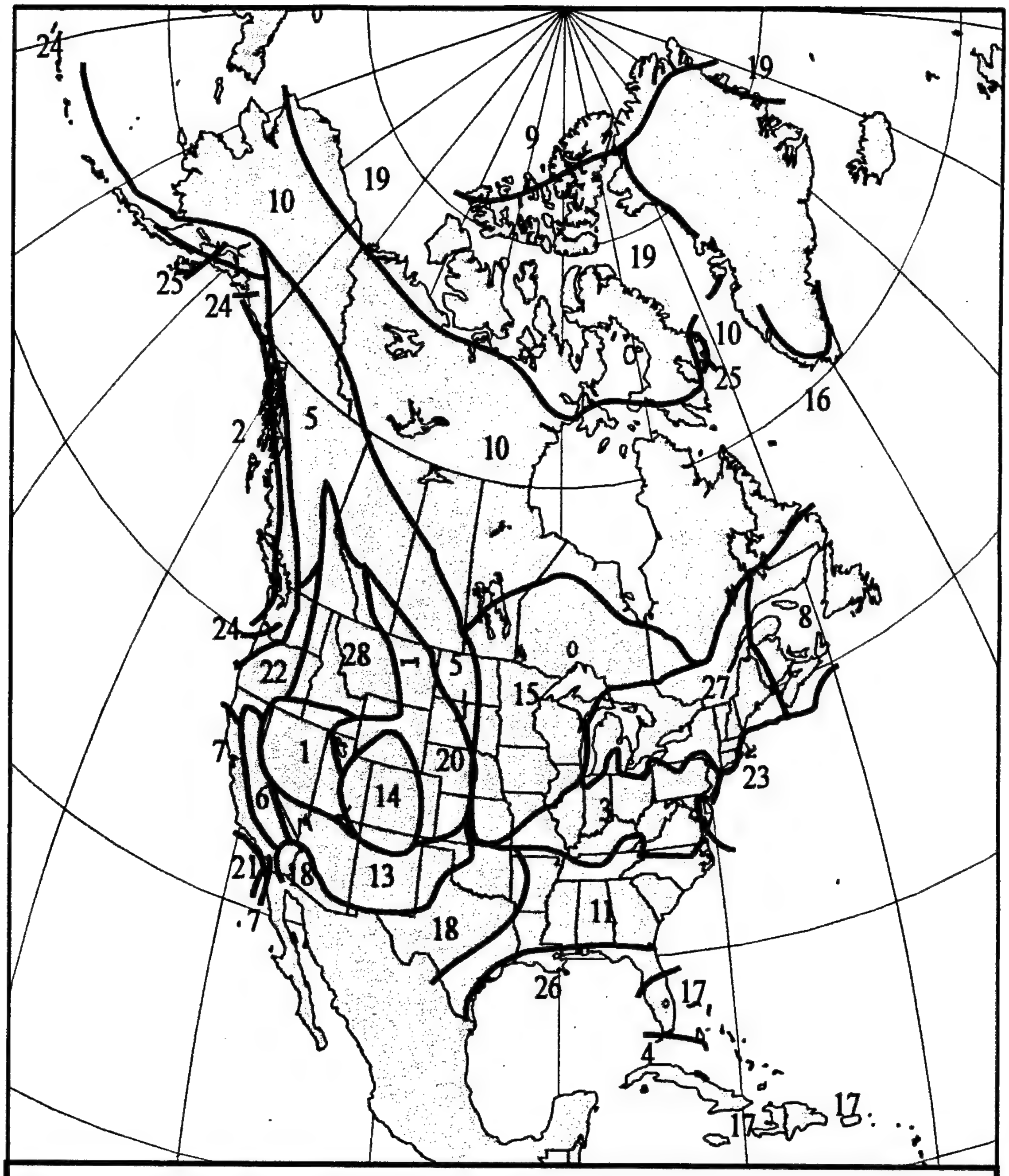

FIGURE 60. NORTH AMERICA TEMPERATURE FREQUENCY GROUPS FOR AUGUST

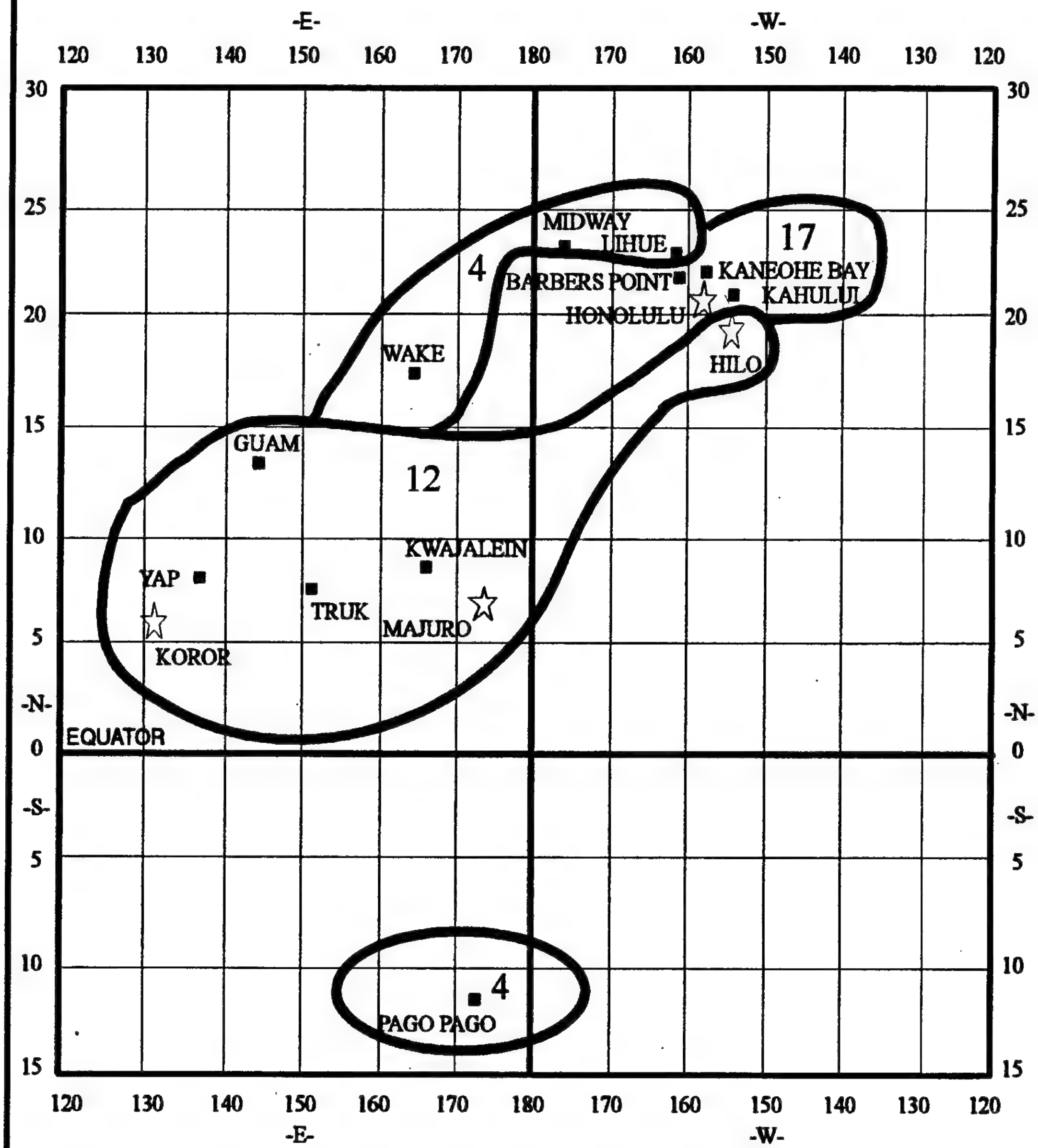

FIGURE 61. PACIFIC ISLANDS TEMPERATURE FREQUENCY GROUPS FOR AUGUST

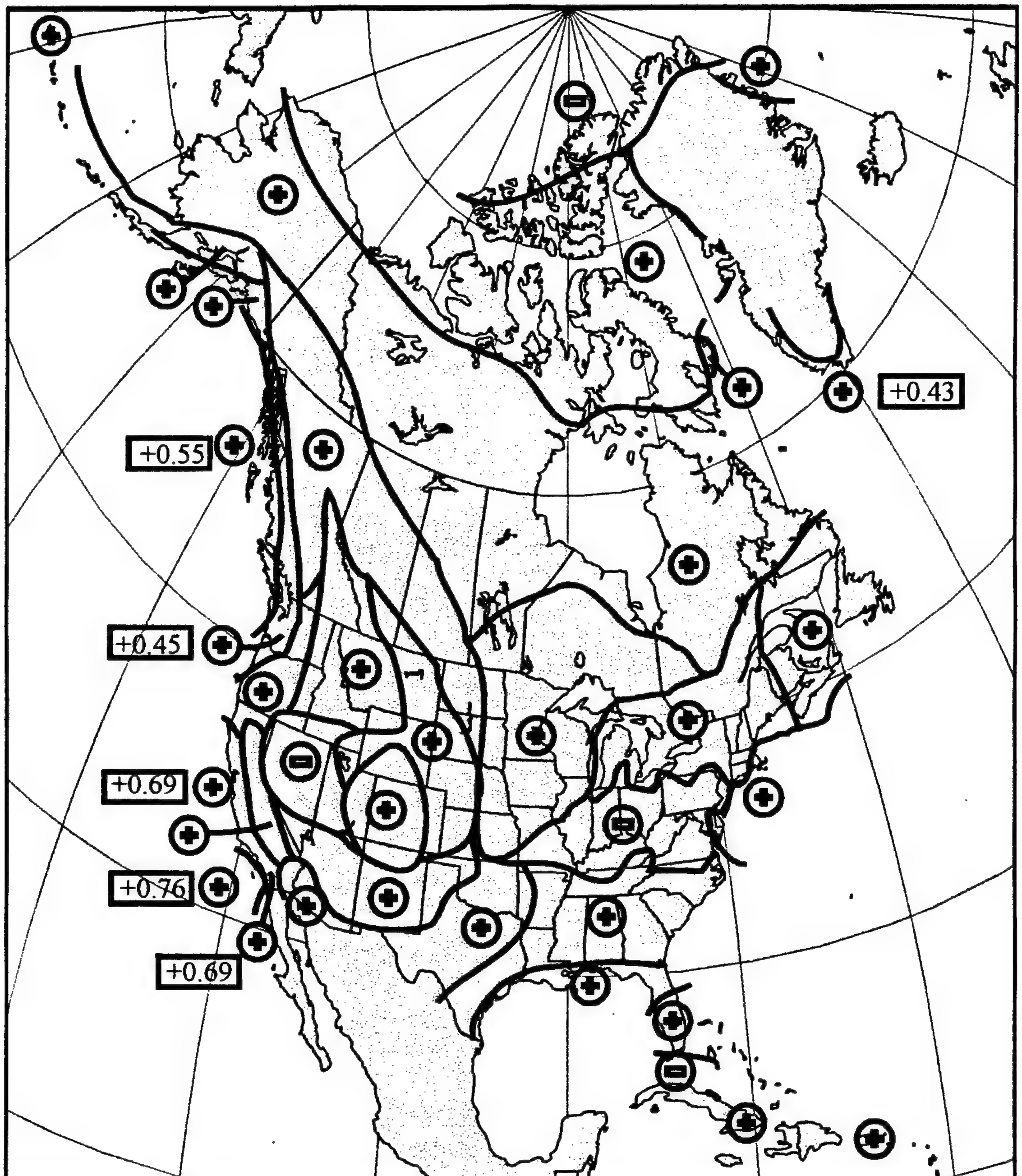

FIGURE 62. NORTH AMERICA TEMPERATURE FREQUENCY GROUP SKEWNESS FOR AUGUST

⊕ = POSITIVE SKEW ⊖ = NEGATIVE SKEW

▭ = VALUES >/= 0.3 OR </= -0.3

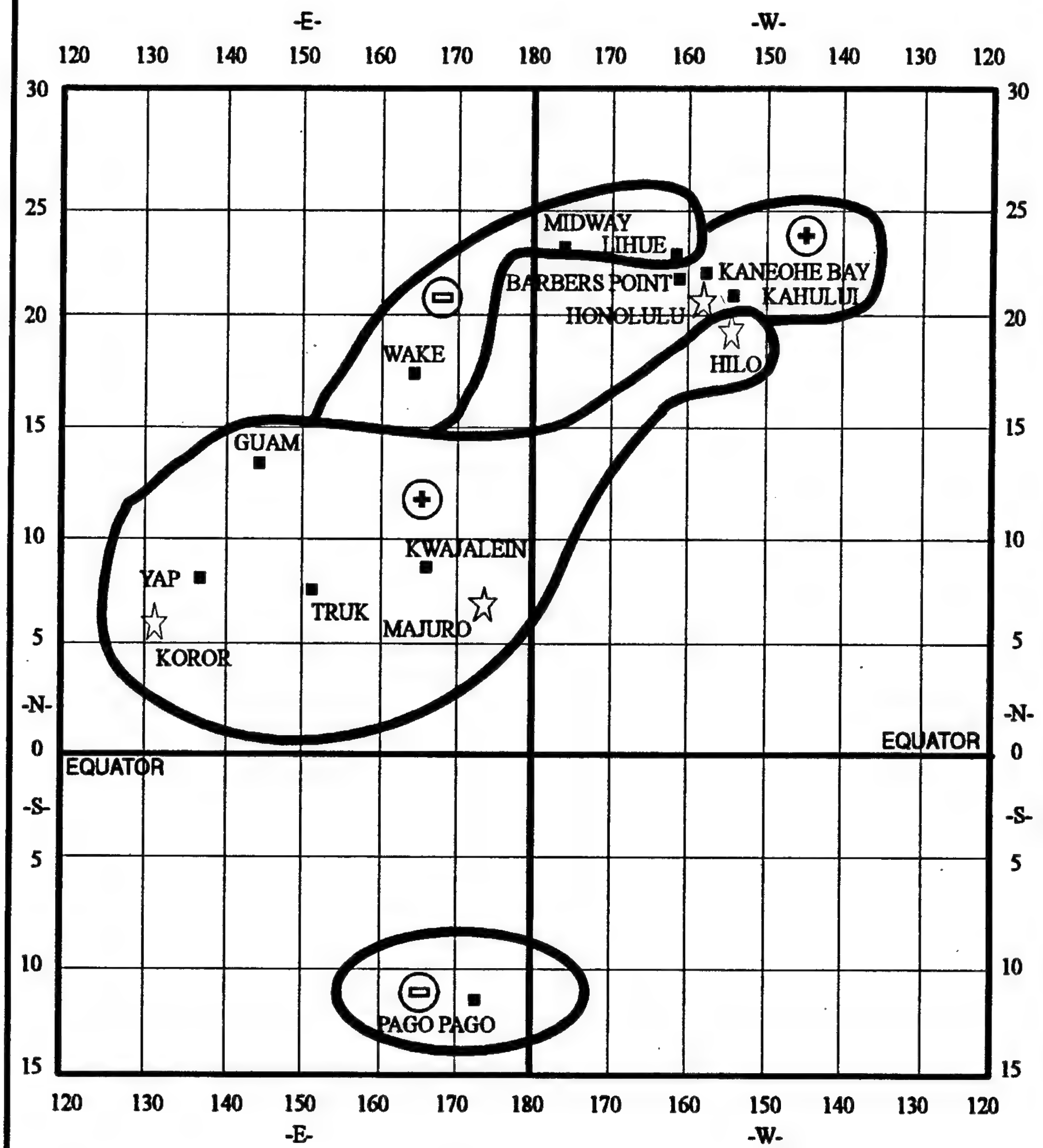

FIGURE 63. PACIFIC ISLANDS TEMPERATURE FREQUENCY GROUP SKEWNESS FOR AUGUST

(+) = POSITIVE SKEW (−) = NEGATIVE SKEW

☐ = VALUES >/= 0.3 OR </= -0.3

the Pacific islands, respectively. Approximately 85 percent of the groups possess a positive skew. Like July, the areas of maximum positive skewness are again along the North American Pacific coast and along the southern Greenland coast. The High Arctic has ceased to have a high positive skew, a condition that will remain until autumn, when skewness will revert back to positive. Sverdrup (1956) notes that the bulk of the central Arctic Basin (Polar Sea) is essentially ice covered throughout the year, although during July and August some large patches of open water can be found. He also notes that during summer, many of the Arctic seas abutting the land masses have areas of open water. Crowe (1971) comments that although incoming solar radiation hovers around a virtually continuous state during the summer months, the presence of sea ice serves to reduce the thermal effects of insolation to a minimum. Hence, surface air temperatures at the positive end of the temperature frequency distribution are capped at a few degrees above the freezing point.

Areas of the Great Basin now exhibit a slight negative skew (-0.1), whereas in June and July the region displayed a positive skew. Both extreme southern Florida and a large region extending from Missouri through the Mid-Atlantic exhibit a negative skew, although both are only slight (-0.06 and -0.04, respectively). The patterns of skewness during August in the Pacific islands are quite similar to July's, with a quite small range of values (-0.06 to +0.15).

August group means for the attribute variables appear in Table 49, group mean normalized temperatures in Table 50, discriminant functions in Table 51, curve-fitting equations in Table 52, and percent probabilities by frequency level in Table 53.

Autumn: September-October-November

The transition season of autumn ranks second to summer in terms of model performance. Autumn averaged 76 percent of its stations having no error, and approximately 93 percent of all generated levels were within tolerance. This is somewhat down from summer and just slightly better than the results for spring. Early autumn may be reminiscent of summer, with warm temperatures and summer-like precipitation. Late autumn, in many areas, is more reminiscent of winter, with subfreezing temperature and winter precipitation patterns. Isotherms, especially those at higher latitudes, fall dramatically throughout the season. At the North Dakota-Canadian border, for example, the difference between the mean daily temperature in September and November is 30°F (Environmental Data Service, 1968).

<u>September</u> -- Model performance for September was quite good. Over 85 percent of all stations had no errors, and approximately 97 percent of all generated levels were within the +/-2.0°C tolerance range. Next to August, September is the second-best month in term of model performance. By early September the axis of the Pacific high has reached

Table 49. Group Means for August

Group	Station Count	Latitude	Elevation	P/E	Continentality	Temperature Range Monthly	Temperature Range Daily	Normalized Mean Daily Max Team	Normalized Mean Daily Min Temp
1	5	40.71	4433	20.9	38.7	78.2	39.0	77.7	27.9
2	2	53.74	104	338.0	11.8	60.0	16.5	53.3	26.0
3	24	38.82	762	89.9	41.5	59.5	20.8	71.0	36.0
4	7	21.59	30	61.2	0.4	27.3	10.3	73.2	35.4
5	4	48.67	2136	32.9	51.0	70.8	27.3	67.0	28.5
6	3	36.76	250	19.0	30.6	62.0	32.0	72.5	21.0
7	8	38.96	43	33.4	6.9	52.3	16.0	54.1	23.4
8	6	46.09	303	174.0	32.3	50.0	15.8	62.8	30.9
9	1	81.60	0	36.1	40.8	50.0	6.0	64.0	52.0
10	5	61.78	245	49.6	45.5	56.6	16.8	59.7	29.5
11	20	32.97	315	88.7	34.3	48.3	19.6	72.0	31.4
12	4	9.79	75	145.1	-10.6	23.8	11.0	73.7	27.1
13	8	34.05	2914	16.1	42.3	54.6	26.0	74.2	26.6
14	6	39.45	5507	25.8	43.5	58.0	27.8	75.2	27.0
15	16	42.46	1098	61.2	53.5	66.2	22.7	67.5	33.2
16	3	63.50	147	106.4	12.0	39.3	9.0	53.6	30.5
17	7	25.18	37	56.1	11.6	32.1	16.0	75.9	26.1
18	6	33.00	814	33.4	42.3	54.7	23.7	73.7	30.4
19	3	70.53	48	23.7	40.8	47.3	9.3	47.0	27.1
20	6	43.05	3552	34.1	44.1	67.5	27.8	72.2	31.1
21	3	32.82	73	13.1	5.0	35.7	10.0	50.9	22.5
22	3	44.62	853	58.3	26.1	74.0	33.0	65.7	21.1
23	5	37.75	19	102.6	33.9	49.2	14.0	64.6	36.3
24	2	47.67	8	168.8	10.6	50.5	15.0	55.8	25.9
25	2	62.63	669	73.5	32.1	51.5	12.5	60.9	36.8
26	11	29.38	66	68.3	29.7	41.5	18.3	70.6	26.4
27	22	42.64	428	100.8	43.6	62.5	20.2	67.6	35.2
28	6	47.12	3272	38.3	38.3	71.0	30.5	67.1	24.2
ALL	198	39.32	985	72.6	34.1	54.6	20.5	68.2	30.6

Table 50. Group Mean Normalized Temperatures: August

Group	Frequency Levels																				
	0	0.001	0.005	0.01	0.03	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	0.95	0.97	0.99	0.995	0.999	1.0
1	0	11.30	16.30	18.84	23.94	26.72	31.49	38.21	43.47	48.48	54.13	60.19	65.77	71.14	77.20	81.25	83.42	86.67	88.33	92.43	100
2	0	6.80	10.74	13.20	18.17	21.20	25.78	30.28	33.03	35.28	37.54	39.88	42.59	46.21	51.13	56.33	60.60	69.13	73.63	83.81	100
3	0	8.95	15.41	18.63	24.43	27.83	33.06	39.20	43.34	46.82	50.29	54.12	58.59	63.70	70.02	74.69	77.54	82.63	85.34	90.51	100
4	0	13.22	19.82	23.18	29.09	31.99	36.48	41.07	44.32	47.16	50.08	53.62	57.55	62.21	67.85	71.82	74.02	78.83	80.71	85.34	100
5	0	5.33	10.36	13.34	19.06	22.01	26.36	32.26	36.91	41.18	45.52	50.06	55.14	60.90	69.26	75.22	78.63	83.42	85.54	91.17	100
6	0	4.76	8.77	10.92	14.74	17.15	20.92	26.43	31.46	36.57	42.46	48.66	55.43	62.79	70.98	76.52	79.76	85.05	87.55	91.89	100
7	0	6.98	11.03	12.98	16.44	18.21	21.04	24.50	27.29	30.01	32.90	36.32	39.99	44.49	50.70	55.74	59.38	66.86	71.01	79.38	100
8	0	5.41	11.37	13.81	18.44	21.38	26.01	31.89	36.20	39.93	43.51	46.90	50.45	55.29	63.12	69.31	73.06	79.09	82.08	88.14	100
9	0	3.80	28.18	31.17	36.55	39.02	42.36	46.22	48.75	51.72	55.33	59.35	63.64	69.16	76.33	80.88	83.66	89.60	92.35	98.09	100
10	0	6.93	11.19	13.84	19.63	22.35	26.67	31.95	35.65	38.99	42.12	45.72	49.80	54.60	62.37	68.93	73.28	79.64	82.21	88.86	100
11	0	6.51	13.47	16.87	22.90	25.84	29.89	34.31	37.77	41.24	45.29	50.42	56.16	62.04	68.65	73.43	76.36	81.53	84.28	89.68	100
12	0	10.57	14.30	18.23	21.30	23.99	28.32	33.31	37.46	41.00	44.42	48.35	53.30	59.40	65.55	70.42	72.90	77.00	78.56	85.10	100
13	0	6.61	11.60	14.33	19.51	22.26	26.54	32.42	37.41	42.29	47.46	53.04	59.34	66.05	73.48	78.30	80.99	85.30	87.46	91.52	100
14	0	6.11	12.00	14.72	19.75	22.34	26.66	32.23	36.86	41.40	46.25	51.64	57.85	64.87	72.71	77.67	80.49	84.80	87.09	91.14	100
15	0	6.85	12.79	15.76	21.25	24.41	29.56	35.88	40.46	44.36	48.09	52.15	56.65	61.82	68.83	74.07	77.24	82.60	85.59	91.26	100
16	0	6.35	11.00	13.62	17.34	19.84	23.73	28.98	32.74	36.25	39.68	42.93	45.71	49.45	56.63	63.32	67.71	76.32	81.30	90.35	100
17	0	6.52	11.02	13.50	17.65	19.92	23.73	28.27	32.25	36.42	41.25	47.34	54.71	61.33	68.63	73.44	75.94	80.78	83.24	88.85	100
18	0	6.63	12.66	15.96	21.60	24.64	28.89	34.62	39.07	43.51	48.10	53.20	58.82	65.15	72.02	76.68	79.18	83.71	86.26	90.81	100
19	0	3.08	7.41	9.34	13.20	15.53	19.28	23.53	26.56	29.43	32.35	35.42	39.05	43.93	50.96	57.06	61.60	70.96	75.21	84.03	100
20	0	8.13	13.97	17.14	22.68	25.36	29.63	35.19	39.70	43.89	48.17	53.17	58.58	65.51	73.22	78.26	81.08	85,67	88.13	92.33	100
21	0	3.09	6.76	8.94	11.79	14.23	16.90	21.09	24.11	27.08	30.08	33.26	37.10	41.61	48.07	53.80	57.15	64.25	69.16	79.62	100
22	0	6.50	9.96	11.96	16.05	18.55	22.49	27.67	31.68	35.82	40.26	45.23	50.81	57.06	65.07	71.10	74.75	80.44	83.35	89.58	100
23	0	10.57	17.84	20.98	26.33	28.96	32.98	37.46	40.62	43.53	46.30	49.22	52.82	57.33	63.18	67.60	70.33	75.56	78.58	85.25	100
24	0	4.05	10.14	12.82	18.02	20.83	24.84	29.47	32.79	35.70	38.19	40.49	43.56	48.07	54.37	59.54	63.42	70.99	75.65	83.99	100
25	0	8.50	15.67	18.65	24.15	27.24	31.40	36.18	39.83	43.08	46.14	49.39	53.33	56.77	62.39	68.31	72.45	79.52	84.19	91.87	100
26	0	5.55	11.54	14.47	18.85	21.24	24.40	28.52	31.83	35.30	39.53	45.39	52.15	58.52	65.55	70.07	72.72	77.72	80.39	86.06	100
27	0	8.53	14.64	17.57	23.25	26.52	31.58	37.82	42.29	45.95	49.54	53.16	57.14	61.82	68.12	72.95	75.74	81.37	84.42	89.98	100
28	0	5.73	10.14	12.45	17.01	19.46	23.50	28.91	33.29	37.56	42.12	47.29	53.02	59.47	67.48	73.20	76.33	81.32	83.78	88.80	100

Table 51. Discriminant Function Values: August

Function value = (a x lat) + (b x elev) + (c x P/E) + (d x K) + (e x mrange) + (f x drange) + (g x nmax) + (h x nmin) + constant

Group	a	b	c	d	e	f	g	h	constant
1	6.612	0.040	0.229	-1.393	22.907	-47.572	35.382	-24.924	-1196.59
2	7.594	0.013	0.887	-2.243	26.563	-58.958	38.799	-30.264	-1295.77
3	5.665	0.014	0.291	-0.414	25.554	-58.916	39.233	-28.504	-1150.27
4	4.196	0.009	0.198	-1.902	23.886	-58.122	38.896	-27.428	-1019.73
5	7.061	0.023	0.165	-0.292	25.629	-57.517	38.548	-29.107	-1193.78
6	6.155	0.007	0.154	-1.167	23.401	-51.401	36.890	-27.849	-1048.65
7	6.452	0.008	0.114	-2.062	24.968	-57.258	37.133	-28.764	-986.30
8	6.476	0.012	0.468	-0.797	24.970	-58.101	38.286	-28.765	-1103.45
9	10.648	0.011	-0.026	-1.033	25.582	-61.091	38.697	-26.849	-1412.76
10	8.512	0.010	0.110	-0.395	25.995	-60.801	39.195	-30.298	-1208.22
11	5.098	0.010	0.290	-0.511	24.687	-57.947	39.030	-28.699	-1075.63
12	3.005	0.010	0.455	-2.221	26.093	-63.679	42.428	-31.524	-1157.70
13	5.489	0.029	0.157	-0.345	24.653	-57.084	39.022	-28.983	-1126.83
14	6.236	0.049	0.210	-0.603	24.925	-57.081	39.229	-28.833	-1265.72
15	5.994	0.016	0.219	0.160	26.043	-59.860	39.277	-29.323	-1171.97
16	8.989	0.011	0.217	-2.068	23.127	-54.159	35.318	-26.429	-1043.29
17	4.817	0.008	0.208	-1.419	26.303	-63.843	42.814	-32.279	-1177.23
18	5.162	0.013	0.168	-0.213	24.613	-57.155	38.801	-28.550	-1084.46
19	9.462	0.008	-0.016	-0.469	24.261	-57.894	35.999	-28.464	-1092.32
20	6.535	0.035	0.200	-0.686	25.250	-56.620	38.607	-28.190	-1214.34
21	5.509	0.008	0.043	-1.675	22.481	-53.580	34.359	-26.410	-800.01
22	7.153	0.013	0.252	-1.758	24.186	-51.245	36.342	-27.697	-1103.30
23	5.404	0.009	0.285	-0.504	24.486	-57.721	37.582	-27.330	-1027.46
24	7.155	0.010	0.446	-2.035	25.125	-57.374	37.684	-28.990	-1081.55
25	8.666	0.015	0.155	-1.173	25.390	-59.474	38.383	-28.319	-1196.13
26	4.829	0.008	0.237	-0.532	24.823	-59.270	39.662	-29.945	-1052.07
27	6.062	0.012	0.305	-0.349	26.069	-59.947	39.426	-29.116	-1170.87
28	7.250	0.032	0.211	-1.118	24.876	-54.459	37.547	-28.342	-1178.86

INPUT VARIABLES
lat = latitude
elev = elevation
P/E = Precipitation Effectiveness Index
K = Continentality
mrange = monthly temperature range
drange = daily temperature range
nmax = normalized mean daily maximum temperature
nmin = normalized mean daily minimum temperature

Table 52. Temperature Frequency Equations: August

Group	If Input Normalized Temperature (T) < 50th Percentile Normalized Temperature (T)	Maximum Error E1	Maximum Error E2	50th Percentile Normalized T	Group	If Input Normalized Temperature (T) > 50th Percentile Normalized Temperature (T)	Maximum Error E3	Maximum Error E4
1	F=0.0066-0.00451915*T+0.000237249*T^2+3.53279e-007*T^3	0.010	0.014	54.13	1	F=0.6134-0.037954*T+0.000947504*T^2-5.30046e-006*T^3	0.008	0.012
2	F=-0.0034+0.00470164*T-0.000571344*T^2+2.14271e-005*T^3	0.007	0.009	37.54	2	F=-5.6764+0.338943*T-0.0064421*T^2+5.41816e-005*T^3-1.69786e-007*T^4	0.002	0.002
3	F=0.0004+0.000986224*T-0.000155086*T^2+6.6756e-006*T^3	0.001	0.008	50.29	3	F=-2.8046+0.108911*T-0.00101506*T^2+3.06038e-006*T^3	0.007	0.007
4	F=-0.0010+0.00481028*T-0.000462745*T^2+1.13739e-005*T^3	0.006	0.007	50.08	4	F=-3.6048+0.141669*T-0.00143475*T^2+4.78297e-006*T^3	0.007	0.009
5	F=0.0073-0.00369956*T+0.000234848*T^2+1.96256e-006*T^3	0.008	0.010	45.52	5	F=-1.5772+0.0694701*T-0.000598681*T^2+1.61479e-006*T^3	0.003	0.004
6	F=0.0106-0.00787672*T+0.000746451*T^2-6.7303e-006*T^3	0.011	0.011	42.46	6	F=-0.2976+0.0181059*T+6.34513e-005*T^2-1.15299e-006*T^3	0.005	0.008
7	F=0.0058-0.00417197*T+0.000160455*T^2+1.33263e-005*T^3	0.011	0.017	32.90	7	F=-1.6074+0.0996308*T-0.00125495*T^2+5.19471e-006*T^3	0.004	0.007
8	F=0.0037-0.00199094*T+0.000101547*T^2+4.82879e-006*T^3	0.004	0.007	43.51	8	F=-2.6827+0.123814*T-0.00138968*T^2+5.19997e-006*T^3	0.006	0.004
9	F=-0.0083+0.00793098*T-0.000639497*T^2+1.32746e-005*T^3-2.13785e-008*T^4	0.014	0.019	55.33	9	F=-2.7206+0.0936261*T-0.000735502*T^2+1.7097e-006*T^3	0.003	0.004
10	F=-0.0012+0.00363358*T-0.000558716*T^2+2.72446e-005*T^3-2.20385e-007*T^4	0.004	0.003	42.12	10	F=-2.2858+0.10924*T-0.00121284*T^2+4.49144e-006*T^3	0.005	0.003
11	F=-0.0043+0.00840104*T-0.00113458*T^2+4.56639e-005*T^3-4.23945e-007*T^4	0.005	0.007	45.29	11	F=-1.1078+0.0478253*T-0.000282469*T^2+1.43308e-007*T^3	0.012	0.013
12	F=0.0032-0.00186437*T+1.98627e-005*T^2+6.27387e-006*T^3	0.007	0.008	44.42	12	F=-1.7333+0.0771521*T-0.000692608*T^2+1.94125e-006*T^3	0.006	0.013
13	F=0.0095-0.00550601*T+0.000370673*T^2-6.70812e-007*T^3	0.011	0.013	47.46	13	F=-0.3743+0.0141837*T+0.000172967*T^2-1.7786e-006*T^3	0.004	0.010
14	F=0.0094-0.00535953*T+0.000340945*T^2+2.20088e-007*T^3	0.011	0.013	46.25	14	F=-0.5231+0.0226431*T+4.25591e-005*T^2-1.17059e-006*T^3	0.005	0.008
15	F=0.0027-0.00100181*T+1.14478e-005*T^2+4.72827e-006*T^3	0.003	0.006	48.09	15	F=-2.4560+0.100553*T-0.000958705*T^2+2.9845e-006*T^3	0.006	0.005
16	F=0.0049-0.00322265*T+0.000188687*T^2+5.36704e-006*T^3	0.007	0.009	39.68	16	F=-4.8281+0.271892*T-0.00479505*T^2+3.77579e-005*T^3-1.11687e-007*T^4	0.007	0.001
17	F=-0.0013+0.0058988*T-0.00109203*T^2+6.18403e-005*T^3-7.68197e-007*T^4	0.005	0.003	41.25	17	F=-0.2120+0.0144653*T+0.000128206*T^2-1.52368e-006*T^3	0.013	0.017
18	F=0.0081-0.00387451*T+0.000196177*T^2+2.14258e-006*T^3	0.010	0.015	48.10	18	F=-0.9050+0.0346815*T-7.7116e-005*T^2-7.97636e-007*T^3	0.006	0.012
19	F=0.0047-0.00307901*T+0.000247766*T^2+1.02191e-005*T^3	0.005	0.010	32.35	19	F=-1.4040+0.0910565*T-0.0011405*T^2+4.70669e-006*T^3	0.007	0.011
20	F=0.0066-0.00316467*T+0.00013018*T^2+3.19621e-006*T^3	0.009	0.013	48.17	20	F=-0.9710+0.0386771*T-0.000150361*T^2-3.96651e-007*T^3	0.005	0.007
21	F=0.0074-0.00633448*T+0.000670967*T^2+3.14713e-006*T^3	0.008	0.011	30.08	21	F=-1.2467+0.087815*T-0.00112892*T^2+4.75616e-006*T^3	0.005	0.009
22	F=0.0080-0.00597208*T+0.000490829*T^2-7.8933e-007*T^3	0.011	0.013	40.26	22	F=-1.0629+0.0559278*T-0.000478812*T^2+1.25427e-006*T^3	0.007	0.007
23	F=-0.0005+0.00363887*T-0.000426933*T^2+1.2648e-005*T^3	0.005	0.009	46.30	23	F=-3.7450+0.161478*T-0.0018248*T^2+6.84471e-006*T^3	0.004	0.002
24	F=0.0003+0.00119641*T-0.000235406*T^2+1.43923e-005*T^3	0.002	0.006	38.19	24	F=-2.5078+0.132192*T-0.00164562*T^2+6.74858e-006*T^3	0.014	0.014
25	F=0.0011+0.00130744*T-0.000236498*T^2+9.68691e-006*T^3	0.004	0.010	46.14	25	F=-3.8120+0.164926*T-0.00188117*T^2+7.13291e-006*T^3	0.006	0.005
26	F=-0.0037+0.00959026*T-0.00162492*T^2+8.24789e-005*T^3-9.9414e-007*T^4	0.008	0.008	39.53	26	F=2.1177-0.137894*T+0.00377865*T^2-3.89254e-005*T^3+1.38101e-007*T^4	0.007	0.002
27	F=0.0016-4.54765e-005*T-7.57115e-005*T^2+5.70285e-006*T^3	0.003	0.007	49.54	27	F=-3.4450+0.137831*T-0.0014162*T^2+4.82145e-006*T^3	0.006	0.004
28	F=0.0087-0.00572575*T+0.000442977*T^2-5.68819e-007*T^3	0.010	0.011	42.12	28	F=-0.9389+0.0469396*T-0.000327717*T^2+5.18397e-007*T^3	0.005	0.008

E1 = Maximum Prediction Error When Computed Frequency < 5%

E2 = Maximum Prediction Error When Computed Frequency Between 5 - 50%

E3 = Maximum Prediction Error When Computed Frequency Between 50 - 95%

E4 = Maximum Prediction Error When Computed Frequency >95%

Table 53. Percent Probability of Predicted Temperatures >2.0C at Each Frequency Level by Group

Month: August

	STANDARDIZED FREQUENCY LEVELS																			% OF ALL >
GROUP	0.001	0.005	0.01	0.03	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	0.95	0.97	0.99	0.995	0.999	2.0C
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
6	0	0	0	0	0	0	33	33	33	33	33	0	0	0	0	0	0	0	0	13.0
7	0	0	0	0	0	0	0	0	12	12	12	0	0	0	0	0	0	12	12	3.3
8	0	0	0	0	17	17	17	17	0	0	0	0	0	0	0	0	0	0	0	3.5
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
10	0	20	20	20	20	20	20	20	20	20	0	0	0	0	0	0	0	0	0	9.5
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5	5	5	0	1.1
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0.3
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
19	0	0	0	0	0	0	0	0	0	33	0	0	0	0	0	0	0	0	0	1.8
20	0	0	0	0	0	0	0	0	0	0	0	17	17	0	0	0	0	0	0	1.8
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	50	50	0	7.9
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
27	5	0	0	0	0	0	0	0	0	0	0	0	5	5	0	0	0	0	0	0.7
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0

about 39°N latitude, but its influence is beginning to ebb (Ludlum, 1982). The Aleutian Low has migrated eastward closer to Alaska. The Azores-Bermuda high has shifted slightly southward and lost some of its strength and there is a peak in hurricane frequency during the month. The primary continental storm track remains in Canada. In the Great Basin, the semi-permanent high pressure feature appears once again, a harbinger that winter is coming soon (Lydolph, 1985; Ludlum, 1982).

Figure 64 shows the September temperature frequency group patterns for North America, and Figure 65 shows the same for the islands in the Pacific Ocean. September is comprised of 30 groups. Southeastern portions of the U.S. are displaying an east-west pattern, similar to those of August. The Mid-Atlantic and Great Lakes regions have their characteristic southwest-northeast configuration. The complexity of this region appears to be the result of elevation, as the differences between the mean values of the other attribute variables for Groups 7 and 26 are minuscule. Surrounded by these two groups is Group 10, which nicely follows the Appalachian Mountains. Group 13 closely corresponds to the Bsk (steppe) climate. Groups in the U.S. Rockies are maintaining their north to south configuration. Like August, Group 25 comprising California's Channel Islands is unique from Coastal California (Group 6). Canada's patterns are similar to those of August. The Pacific islands are comprised of 4 groups, differentiated primarily by Precipitation Effectiveness (P/E).

Figures 66 and 67 show the group mean September skewness for North America and the Pacific islands, respectively. About 65 percent of the groups have a positive skew. This is down from 85 percent in August. An area of high positive skewness continues to persist along the North American Pacific Coast. However, the Aleutians and western coastal Alaska, positively skewed in the previous month, are now negative; perhaps an indication of the eastward movement of the Aleutian low. Southern Greenland also shows a high positive skew. During September, prevailing winds in the region generally range from the south to southwest.

The High Arctic remains negatively skewed, a trend it commenced in August. The southeastern portions of the U.S. also show a negative skew -- prevailing winds at most locations are from the East and Northeast during September. The Great Basin is the other region of negative skewness, an indication of the re-establishment of the high pressure system in that area. The groups of the Pacific islands exhibit both positive and negative skewness. However, skewness is minimal (-0.1 to +0.1).

September group means for the attribute variables appear in Table 54, group mean normalized temperatures in Table 55, discriminant functions in Table 56, curve-fitting equations in Table 57, and percent probabilities by frequency level in Table 58.

<u>October</u> -- Model performance during October was worse than the preceding five months. Approximately 75 percent of all the stations had no errors and 93 percent of all the

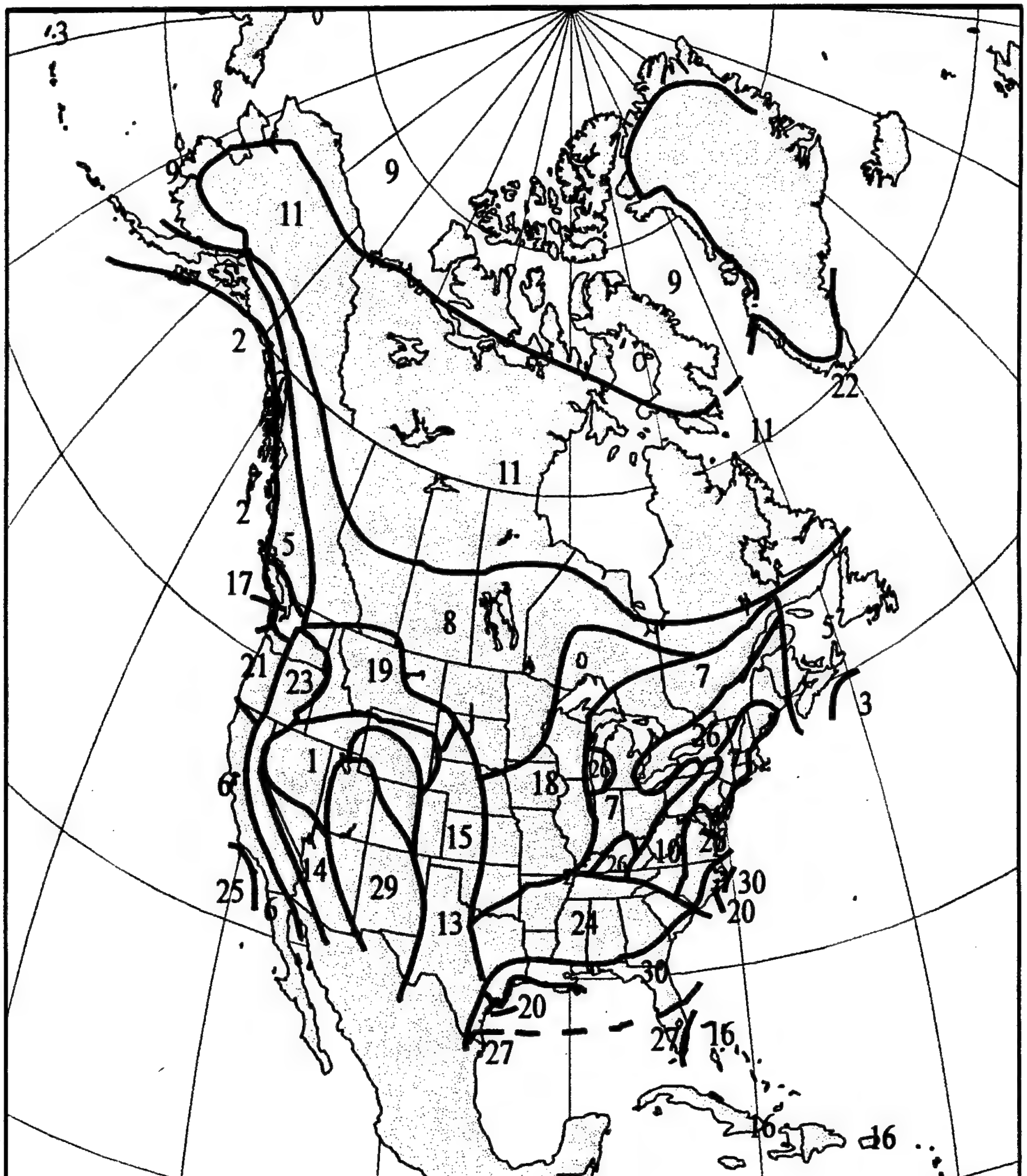

FIGURE 64. NORTH AMERICA TEMPERATURE FREQUENCY GROUPS FOR SEPTEMBER

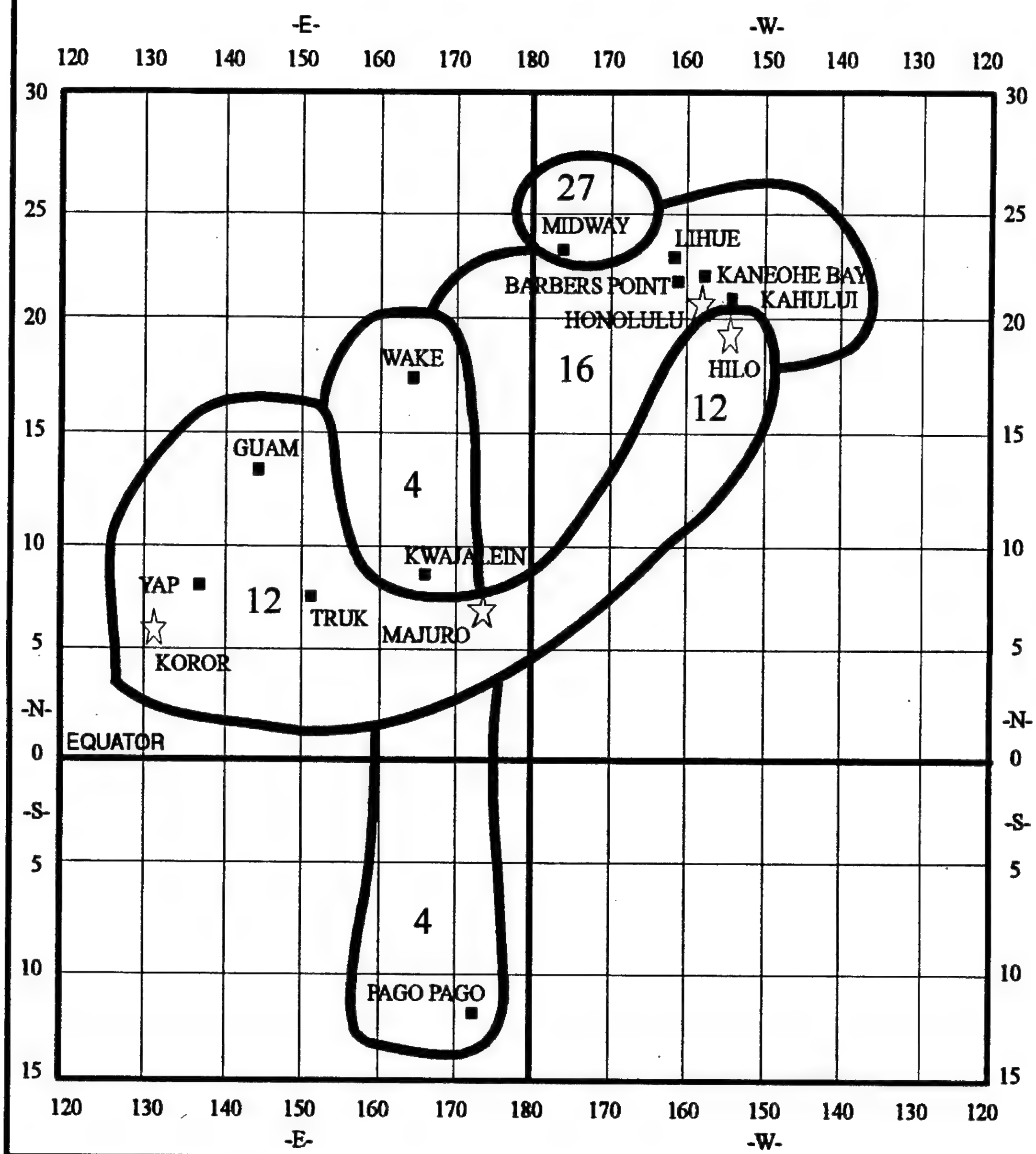

FIGURE 65. PACIFIC ISLANDS TEMPERATURE FREQUENCY GROUPS FOR SEPTEMBER

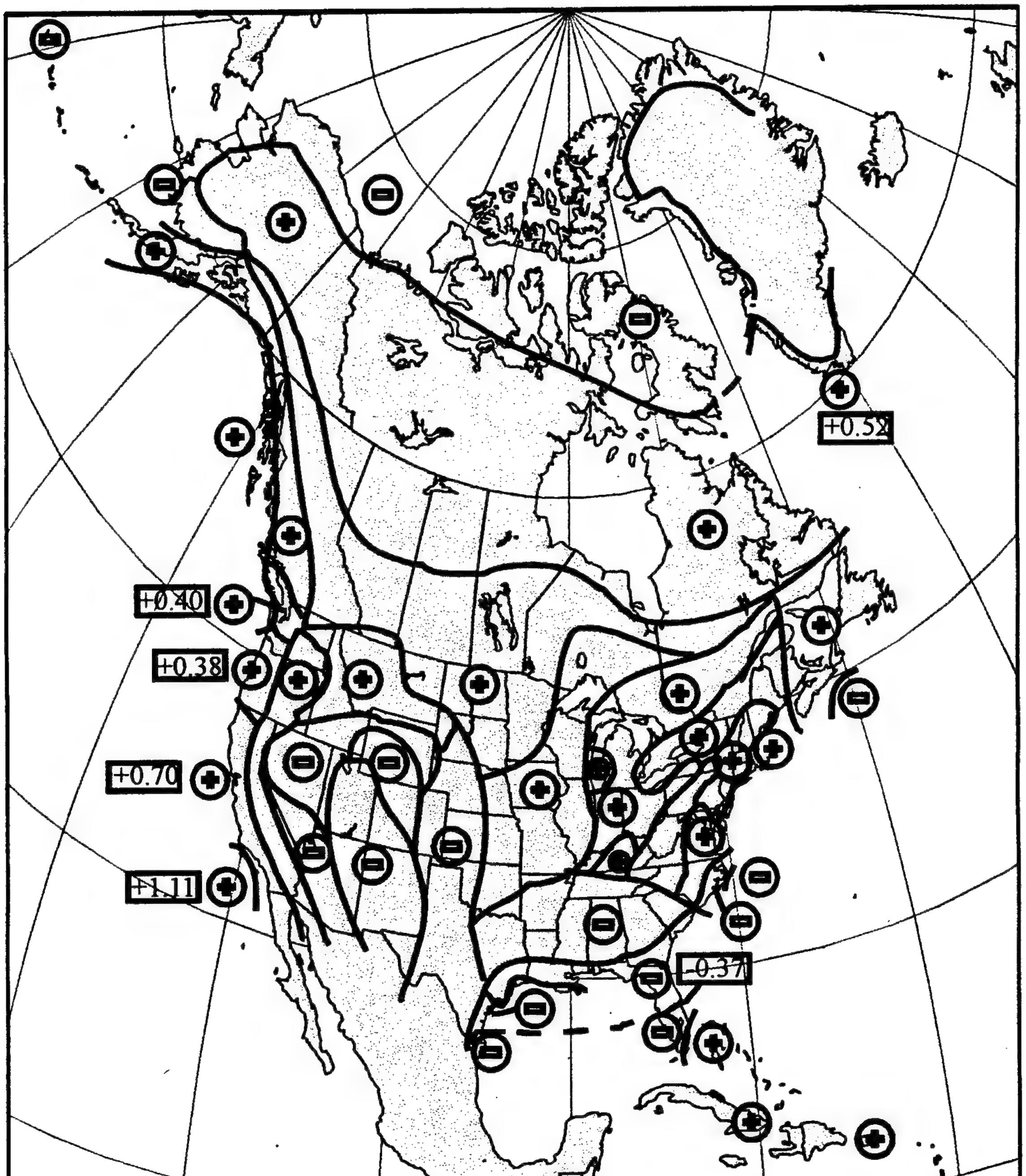

FIGURE 66. NORTH AMERICA TEMPERATURE FREQUENCY GROUP SKEWNESS FOR SEPTEMBER

⊕ = POSITIVE SKEWNESS ⊖ = NEGATIVE SKEWNESS

▭ = VALUES >/= 0.3 OR </= -0.3

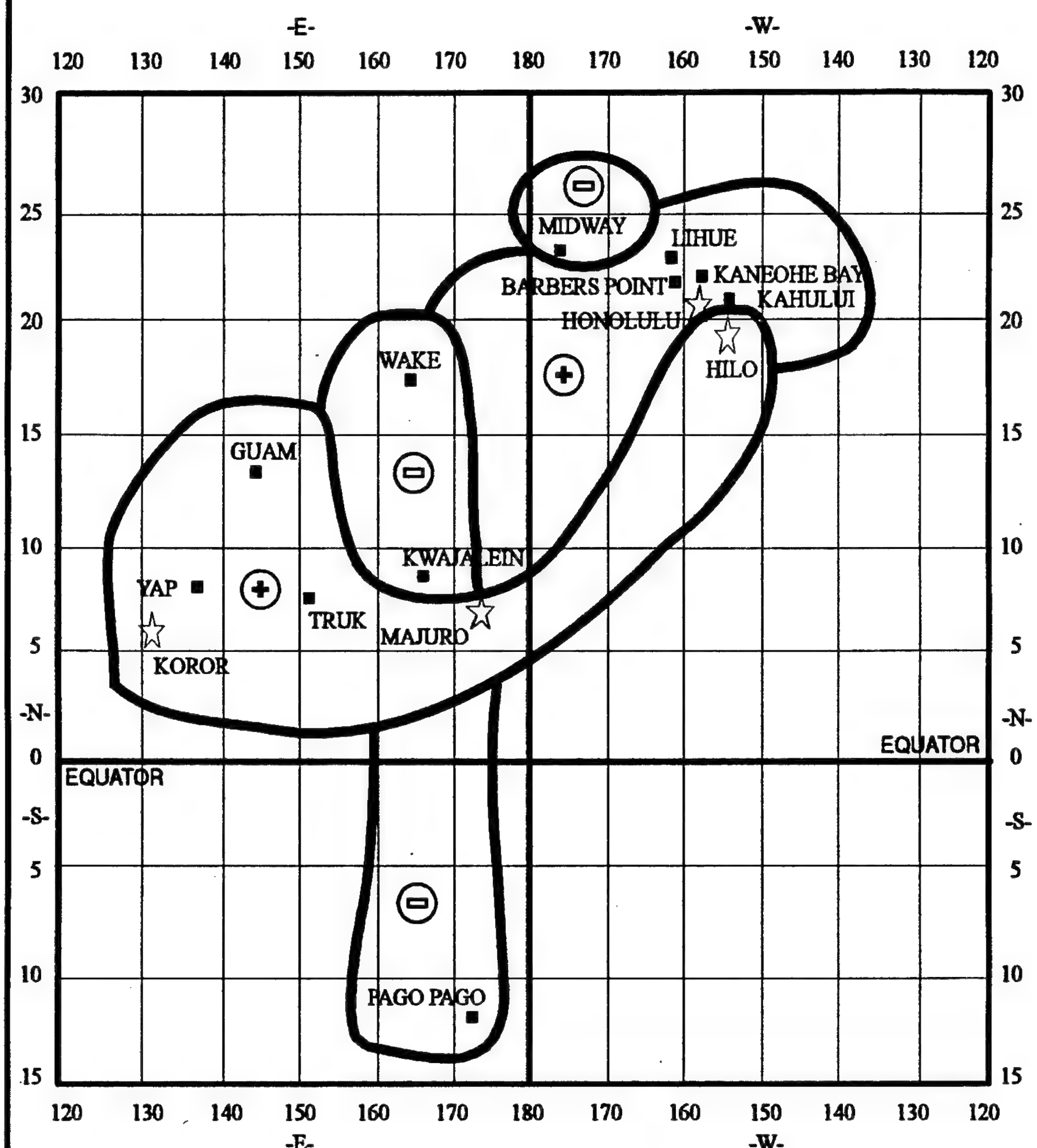

FIGURE 67. PACIFIC ISLANDS TEMPERATURE FREQUENCY GROUP SKEWNESS FOR SEPTEMBER

(+) = POSITIVE SKEW (−) = NEGATIVE SKEW

= VALUES >/= 0.3 OR </= -0.3

Table 54. Group Means for September

Group	Station Count	Latitude	Elevation	P/E	Continentality	Temperature Range Monthly	Temperature Range Daily	Normalized Mean Daily Max Team	Normalized Mean Daily Min Temp
1	6	40.91	4351	22.3	39.7	83.2	37.0	74.1	29.6
2	2	53.74	104	338.0	11.8	62.5	17.5	58.6	30.9
3	1	43.93	13	161.5	25.7	48.0	10.0	66.6	45.8
4	2	11.53	9	143.5	-9.1	25.5	10.0	80.3	41.1
5	7	46.53	260	172.0	29.6	52.9	14.7	60.9	33.0
6	4	35.75	32	25.4	6.5	61.3	18.8	53.4	22.9
7	21	41.49	582	99.6	43.5	69.2	21.0	62.7	32.3
8	6	47.24	1593	41.8	56.0	83.0	24.8	60.0	30.1
9	7	69.35	236	39.1	38.0	54.4	9.4	62.1	44.3
10	6	37.01	1257	87.4	37.8	66.0	22.0	68.9	35.6
11	4	60.47	262	57.2	47.3	64.3	16.0	59.3	34.3
12	3	10.14	97	150.8	-10.5	24.0	11.3	75.0	27.7
13	6	35.87	2837	28.6	44.7	75.7	26.0	71.3	37.0
14	4	34.33	2035	8.3	40.7	68.8	28.8	75.7	33.9
15	4	40.64	5717	31.1	41.0	79.8	28.3	75.2	39.6
16	9	22.65	35	48.3	3.4	28.7	13.6	75.8	28.8
17	2	48.50	54	57.2	8.7	54.0	16.5	59.2	28.1
18	16	40.45	1033	64.7	51.5	73.8	22.9	66.9	35.8
19	6	46.53	3407	34.7	40.2	81.2	28.3	64.0	29.1
20	9	31.67	59	65.4	32.8	53.1	17.6	72.3	39.2
21	2	45.54	102	141.6	13.0	70.0	24.0	60.3	26.4
22	3	63.50	147	106.4	12.0	38.3	7.0	47.2	28.8
23	6	38.65	553	21.6	31.8	72.0	31.2	67.8	24.5
24	14	33.39	485	84.5	37.4	63.9	21.3	75.0	41.7
25	5	34.03	67	18.1	5.3	56.6	12.4	41.8	19.9
26	18	41.30	349	94.6	42.5	67.9	19.6	64.7	35.8
27	4	27.29	36	56.9	15.2	33.3	12.8	76.0	38.2
28	3	50.68	2761	44.8	35.1	74.7	23.3	62.1	30.8
29	5	36.01	4397	18.8	45.5	65.6	27.0	73.1	31.9
30	13	30.65	59	85.0	29.5	53.5	17.3	78.3	46.0
ALL	198	39.32	985	72.6	34.1	62.7	20.4	67.3	34.5

Table 55. Group Mean Normalized Temperatures: September

Group	Frequency Levels																				
	0	0.001	0.005	0.01	0.03	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	0.95	0.97	0.99	0.995	0.999	1.0
1	0	8.95	14.30	17.29	22.50	25.27	29.81	35.66	40.49	45.16	50.03	55.34	61.24	67.91	75.56	80.35	82.92	87.17	89.43	93.49	100
2	0	6.01	11.67	14.28	19.53	22.73	28.09	34.39	38.18	41.13	43.59	45.95	48.58	51.86	56.94	61.78	65.67	72.76	76.06	84.23	100
3	0	14.69	25.05	29.37	34.84	37.64	41.13	45.51	48.84	51.62	54.14	56.40	58.74	61.59	65.26	68.06	69.88	73.31	74.61	79.50	100
4	0	13.83	19.65	23.35	31.70	35.27	40.60	45.93	49.64	52.43	54.92	57.61	61.67	66.62	72.07	76.44	78.70	82.68	85.03	90.74	100
5	0	5.57	11.65	14.63	20.22	23.40	28.19	33.78	38.20	41.90	45.40	48.83	52.59	57.05	62.31	67.11	70.92	78.10	82.15	89.58	100
6	0	6.98	10.94	12.91	16.50	18.32	21.21	24.73	27.43	30.05	32.76	35.88	39.48	43.69	50.28	56.57	61.37	70.88	75.58	85.22	100
7	0	5.00	10.09	12.84	18.35	21.48	26.64	33.37	38.30	42.47	46.32	50.03	53.91	58.44	65.03	70.43	73.82	79.82	82.79	88.71	100
8	0	6.11	10.34	13.01	18.13	21.07	25.79	31.45	35.54	39.35	43.03	46.93	51.47	56.77	64.16	70.28	74.14	80.53	83.84	89.85	100
9	0	5.59	13.06	16.49	23.64	27.98	33.95	40.94	45.68	48.86	52.10	55.48	59.26	63.35	68.83	73.32	76.48	82.50	85.93	93.02	100
10	0	5.72	11.46	14.38	20.42	24.12	29.85	37.06	42.24	46.41	49.90	53.28	57.16	62.34	69.46	74.57	77.38	82.27	84.81	90.63	100
11	0	8.69	13.12	16.06	21.28	24.13	28.42	34.28	38.66	42.13	45.20	48.42	51.97	56.11	62.63	67.71	71.09	78.02	82.49	89.45	100
12	0	11.06	17.27	19.11	22.08	24.79	28.69	33.64	37.81	41.48	45.10	49.26	54.57	60.89	66.85	71.70	73.88	77.19	78.97	84.50	100
13	0	8.40	14.39	17.28	23.24	26.79	32.31	38.82	43.24	47.13	50.99	55.08	60.04	66.02	73.32	78.65	81.44	85.93	88.09	92.01	100
14	0	11.77	18.37	21.13	26.20	28.95	33.49	39.57	44.52	49.11	53.75	58.66	63.66	69.12	75.45	79.79	82.33	86.15	88.23	91.71	100
15	0	11.02	17.58	20.92	27.30	30.68	35.81	42.13	46.74	50.80	54.90	59.26	64.41	70.58	77.90	82.38	85.00	89.19	91.33	94.94	100
16	0	5.19	11.65	13.97	19.43	22.08	26.62	31.87	35.89	39.84	44.08	49.09	54.96	60.99	67.80	72.14	75.03	79.71	82.20	87.13	100
17	0	7.92	12.89	15.29	19.26	21.46	25.32	30.22	33.77	36.71	39.70	42.99	46.84	51.36	57.31	63.82	68.14	76.28	80.67	87.57	100
18	0	5.77	11.51	14.63	20.79	24.14	29.49	36.27	41.33	45.63	49.52	53.40	57.73	62.82	69.81	75.36	78.76	84.57	87.28	92.33	100
19	0	6.36	10.90	13.29	18.17	21.21	25.93	31.71	35.97	39.86	43.82	48.02	52.81	59.07	67.36	73.61	77.07	82.86	85.47	90.12	100
20	0	6.05	13.58	17.38	24.82	28.94	35.15	41.49	45.50	48.81	52.09	55.68	59.84	64.62	70.99	75.35	78.03	82.79	85.36	90.53	100
21	0	7.60	12.50	14.60	19.33	21.89	25.87	31.03	34.69	37.54	40.22	43.14	46.66	51.12	58.16	64.21	68.94	77.85	81.45	88.18	100
22	0	2.19	5.08	8.05	12.08	14.44	18.46	23.49	27.36	30.98	34.52	38.21	42.28	47.01	54.17	58.61	62.25	69.04	73.78	86.09	100
23	0	5.74	10.44	12.74	17.00	19.44	23.40	28.72	33.19	37.46	42.00	46.86	52.56	59.04	67.51	73.57	76.80	81.86	84.48	89.04	100
24	0	9.52	16.55	20.32	27.26	31.04	37.06	44.00	48.35	51.64	54.70	58.16	62.59	68.05	74.68	79.06	81.59	85.94	88.34	92.61	100
25	0	6.44	9.67	11.29	13.88	15.37	17.39	20.00	22.20	24.28	26.55	29.04	31.94	35.49	40.99	46.40	50.83	60.28	65.91	79.06	100
26	0	6.88	12.25	15.29	21.13	24.58	29.54	36.08	40.84	44.98	48.74	52.49	56.30	60.77	67.55	72.96	76.36	82.23	84.95	90.96	100
27	0	11.90	20.80	24.15	29.74	32.23	36.47	41.21	44.32	47.35	50.78	54.95	60.19	66.03	72.64	76.61	79.15	83.20	84.95	89.54	100
28	0	6.22	11.83	14.69	19.75	22.71	27.21	32.76	36.61	39.45	42.99	47.18	52.18	58.27	65.97	73.00	76.83	82.95	86.08	90.89	100
29	0	5.05	11.41	14.53	20.69	24.01	29.42	35.91	40.62	44.75	49.03	53.78	59.42	66.02	73.51	78.50	81.44	85.90	88.17	92.19	100
30	0	10.61	19.72	24.78	32.87	37.02	42.71	48.64	52.20	55.15	58.12	61.53	65.78	70.91	76.73	80.56	82.77	86.66	88.71	92.88	100

Table 56. Discriminant Function Values: September

Function value = (a x lat) + (b x elev) + (c x P/E) + (d x K) + (e x mrange) + (f x drange) + (g x nmax) + (h x nmin) + constant

Group	a	b	c	d	e	f	g	h	constant
1	4.645	0.026	0.202	-0.608	12.689	-34.357	27.834	-21.864	-744.23
2	5.977	-0.004	1.107	-2.842	15.806	-43.914	32.621	-26.502	-990.86
3	4.997	-0.005	0.547	-1.204	13.256	-40.130	29.968	-21.867	-756.52
4	2.148	0.001	0.631	-2.673	16.589	-52.476	38.529	-29.968	-954.18
5	5.224	-0.002	0.571	-1.224	14.405	-42.543	31.422	-25.013	-767.30
6	4.844	-0.006	0.129	-2.609	16.060	-44.822	31.759	-27.487	-689.06
7	4.244	-0.002	0.374	-0.354	14.982	-42.305	31.034	-25.084	-742.51
8	4.655	0.004	0.178	0.150	15.423	-42.493	30.671	-25.520	-772.36
9	8.553	-0.006	0.035	-1.195	13.340	-41.134	30.364	-22.870	-881.52
10	3.931	0.004	0.369	-0.546	14.680	-42.169	31.462	-24.803	-747.65
11	6.945	-0.006	0.138	-0.558	14.531	-42.659	31.149	-25.043	-822.57
12	2.029	0.004	0.653	-2.986	19.292	-60.600	43.227	-36.388	-1083.78
13	3.628	0.016	0.209	-0.129	14.533	-41.261	30.773	-24.203	-753.83
14	3.975	0.008	0.141	-0.270	13.710	-39.340	30.635	-23.854	-736.53
15	4.209	0.040	0.243	-0.561	14.541	-42.028	31.456	-24.602	-878.09
16	3.808	0.000	0.264	-2.361	17.842	-56.619	41.109	-34.171	-986.03
17	6.622	-0.006	0.185	-2.742	15.422	-44.924	32.802	-27.283	-790.58
18	3.973	0.000	0.278	0.190	14.760	-41.691	30.823	-24.415	-758.27
19	5.103	0.020	0.188	-0.834	14.842	-41.129	30.475	-25.235	-769.94
20	3.661	-0.005	0.295	-0.556	14.299	-42.689	32.023	-24.524	-743.59
21	5.642	-0.007	0.500	-2.564	15.562	-42.175	31.469	-26.211	-791.50
22	8.324	-0.003	0.242	-2.529	12.230	-37.692	27.655	-22.247	-700.03
23	4.848	-0.005	0.146	-1.050	13.927	-37.903	29.689	-24.267	-700.85
24	3.578	-0.003	0.374	-0.420	14.449	-41.784	31.674	-23.946	-776.24
25	4.409	-0.004	0.082	-2.543	16.113	-45.299	30.509	-27.306	-613.36
26	4.279	-0.004	0.358	-0.381	14.978	-42.627	31.278	-24.835	-757.53
27	3.918	-0.002	0.273	-1.482	14.915	-47.423	35.389	-27.449	-818.94
28	5.807	0.015	0.187	-1.251	15.350	-43.585	31.739	-26.300	-798.75
29	3.835	0.030	0.184	0.013	13.868	-41.497	31.454	-25.103	-785.62
30	3.571	-0.005	0.377	-0.732	14.204	-42.533	32.358	-23.789	-795.64

INPUT VARIABLES
lat = latitude
elev = elevation
P/E = Precipitation Effectiveness Index
K = Continentality
mrange = monthly temperature range
drange = daily temperature range
nmax = normalized mean daily maximum temperature
nmin = normalized mean daily minimum temperature

Table 57, Temperature Frequency Equations: September

Group	If Input Normalized Temperature (T) < 50th Percentile Normalized Temperature (T)	Maximum Error E1	Maximum Error E2	50th Percentile Normalized T	Group	If Input Normalized Temperature (T) > 50th Percentile Normalized Temperature (T)	Maximum Error E3	Maximum Error E4
1	F=0.0074-0.00418786*T+0.000217966*T^2+1.35684e-006*T^3	0.012	0.014	50.03	1	F=-0.5053+0.0163652*T+0.000162223*T^2-1.75756e-006*T^3	0.003	0.007
2	F=-0.0037+0.00294291*T-0.000290649*T^2+1.1139e-005*T^3	0.004	0.006	43.59	2	F=-8.7381+0.468745*T-0.00846499*T^2+6.7861e-005*T^3-2.03475e-007*T^4	0.004	0.003
3	F=-0.0027+0.00713355*T-0.000573772*T^2+1.13356e-005*T^3	0.013	0.008	54.14	3	F=-11.2106+0.437042*T-0.00517852*T^2+2.02912e-005*T^3	0.008	0.003
4	F=-0.0036+0.00591599*T-0.000463796*T^2+9.48139e-006*T^3	0.013	0.008	54.92	4	F=-4.5480+0.165407*T-0.00162636*T^2+5.26845e-006*T^3	0.011	0.007
5	F=0.0032-0.00108274*T+7.89702e-006*T^2+5.74095e-006*T^3	0.004	0.007	45.40	5	F=-3.4390+0.150426*T-0.00169379*T^2+6.33364e-006*T^3	0.009	0.005
6	F=0.0047-0.00270007*T+9.50015e-006*T^2+1.67566e-005*T^3	0.009	0.015	32.76	6	F=-1.5516+0.0977953*T-0.00123705*T^2+5.14725e-006*T^3	0.010	0.014
7	F=0.0032-0.00164935*T+0.000114133*T^2+3.35232e-006*T^3	0.003	0.004	46.32	7	F=-3.0802+0.132151*T-0.00142364*T^2+5.10042e-006*T^3	0.006	0.001
8	F=0.0042-0.00209247*T+0.000113253*T^2+4.83431e-006*T^3	0.004	0.010	43.03	8	F=-2.0678+0.0965858*T-0.00101112*T^2+3.51928e-006*T^3	0.004	0.001
9	F=-0.0033+0.00249245*T-0.000212544*T^2+6.71539e-006*T^3	0.004	0.007	52.10	9	F=-4.6702+0.179597*T-0.0018897*T^2+6.60487e-006*T^3	0.011	0.004
10	F=0.0006-6.86436e-005*T-1.48182e-005*T^2+4.34876e-006*T^3	0.006	0.001	49.90	10	F=-3.3020+0.131878*T-0.00134217*T^2+4.53509e-006*T^3	0.002	0.001
11	F=0.0015-0.000228021*T-7.13056e-005*T^2+7.12421e-006*T^3	0.002	0.004	45.20	11	F=-3.4533+0.152477*T-0.00173685*T^2+6.57526e-006*T^3	0.004	0.001
12	F=-0.0003+0.00592481*T-0.000891624*T^2+3.87815e-005*T^3-3.64968e-007*T^4	0.002	0.004	45.10	12	F=-1.3715+0.0593856*T-0.00043106*T^2+7.40586e-007*T^3	0.013	0.016
13	F=0.0018-0.000175766*T-5.50963e-005*T^2+4.96882e-006*T^3	0.002	0.008	50.99	13	F=-1.9102+0.0719674*T-0.000542194*T^2+1.13321e-006*T^3	0.003	0.005
14	F=-0.0006+0.00517138*T-0.000658659*T^2+2.46397e-005*T^3-2.03628e-007*T^4	0.004	0.001	53.75	14	F=-1.1265+0.0323438*T+4.13543e-003*T^2-1.52679e-006*T^3	0.006	0.010
15	F=0.0026-0.000244733*T-7.02971e-005*T^2+4.43359e-006*T^3	0.004	0.010	54.90	15	F=-1.2964+0.0395592*T-7.30634e-005*T^2-9.31612e-007*T^3	0.004	0.004
16	F=-0.0028+0.00519412*T-0.000798719*T^2+3.93327e-005*T^3-4.07975e-007*T^4	0.006	0.006	44.08	16	F=2.4024-0.161041*T+0.00429531*T^2-4.34201e-005*T^3+1.51682e-007*T^4	0.007	0.001
17	F=0.0025-0.000949616*T-6.52229e-005*T^2+1.03384e-005*T^3	0.004	0.008	39.70	17	F=-2.3809+0.120014*T-0.00141576*T^2+5.53924e-006*T^3	0.010	0.007
18	F=0.0031-0.00126815*T+5.54178e-005*T^2+3.53181e-006*T^3	0.003	0.005	49.52	18	F=-2.8315+0.113094*T-0.0011028*T^2+3.54778e-006*T^3	0.004	0.002
19	F=0.0048-0.00262938*T+0.000159996*T^2+3.72319e-006*T^3	0.005	0.010	43.82	19	F=-1.6502+0.0766001*T-0.000727944*T^2+2.26866e-006*T^3	0.001	0.002
20	F=-0.0033+0.00286478*T-0.000254425*T^2+7.41343e-006*T^3	0.005	0.007	52.09	20	F=-3.4369+0.129632*T-0.00124214*T^2+3.89199e-006*T^3	0.006	0.007
21	F=0.0006+0.000716324*T-0.000185206*T^2+1.1893e-005*T^3	0.001	0.004	40.22	21	F=-2.5123+0.125613*T-0.00149404*T^2+5.89522e-006*T^3	0.007	0.009
22	F=0.0063-0.00441026*T+0.000528435*T^2+5.55458e-007*T^3	0.007	0.008	34.52	22	F=-1.5579+0.092388*T-0.0011036*T^2+4.35562e-006*T^3	0.004	0.007
23	F=0.0088-0.00600207*T+0.000464589*T^2-8.88224e-007*T^3	0.011	0.011	42.00	23	F=-1.0290+0.051716*T-0.000403089*T^2+8.85738e-007*T^3	0.004	0.006
24	F=-0.0032+0.00298921*T-0.000254608*T^2+6.71368e-006*T^3	0.006	0.007	54.70	24	F=-2.9751+0.104662*T-0.000875063*T^2+2.2568e-006*T^3	0.006	0.006
25	F=-0.0011+0.0173166*T-0.00397743*T^2+0.000268109*T^3-4.36516e-006*T^4	0.008	0.007	26.55	25	F=-2.2913+0.185308*T-0.00388643*T^2+3.57924e-005*T^3-1.21676e-007*T^4	0.003	0.003
26	F=0.0030-0.00115455*T+3.1527e-005*T^2+4.18339e-006*T^3	0.005	0.006	48.74	26	F=-3.4121+0.139307*T-0.00146352*T^2+5.11534e-006*T^3	0.007	0.001
27	F=-0.0015+0.00621656*T-0.000655471*T^2+1.87745e-005*T^3-8.58972e-008*T^4	0.008	0.015	50.78	27	F=-1.5408+0.0555261*T-0.000303587*T^2+2.01755e-008*T^3	0.005	0.012
28	F=0.0020-0.000230812*T-8.1274e-005*T^2+8.41997e-006*T^3	0.003	0.016	42.99	28	F=-1.64050.077836*T-0.000758164*T^2+2.43723e-006*T^3	0.005	0.001
29	F=0.0043-0.00174638*T+7.92885e-005*T^2+3.39803e-006*T^3	0.005	0.010	49.03	29	F=-1.0252+0.0393869*T-0.000147182*T^2-4.45201e-007*T^3	0.005	0.007
30	F=-0.0060+0.00539586*T-0.000397384*T^2+7.80296e-006*T^3	0.004	0.014	58.12	30	F=-3.2427+0.103462*T-0.000757765*T^2+1.4702e-006*T^3	0.007	0.008

E1 = Maximum Prediction Error When Computed Frequency < 5%

E2 = Maximum Prediction Error When Computed Frequency Between 5 - 50%

E3 = Maximum Prediction Error When Computed Frequency Between 50 - 95%

E4 = Maximum Prediction Error When Computed Frequency >95%

Table 58. Percent Probability of Predicted Temperatures >2.0C at Each Frequency Level by Group

Month: September

GROUP	0.001	0.005	0.01	0.03	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	0.95	0.97	0.99	0.995	0.999	% OF ALL > 2.0C
	STANDARDIZED FREQUENCY LEVELS																			
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
7	0	0	0	0	0	0	0	0	5	5	5	5	5	5	5	5	0	0	0	2.1
8	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	0	0	14.9
9	0	0	0	0	0	0	0	0	0	0	14	14	14	14	14	14	28	28	0	7.5
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
11	0	25	25	25	25	25	25	25	25	25	25	25	25	25	25	0	0	0	0	18.4
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	50	50	7.9
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
20	0	0	0	0	0	11	0	0	0	0	0	11	11	0	0	0	0	0	0	1.8
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	50	0	0	0	5.3
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
23	0	0	0	0	0	17	17	17	17	17	0	0	0	0	0	0	0	17	17	6.1
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
25	0	0	0	0	20	20	20	20	20	0	0	0	0	0	0	0	0	0	0	5.3
26	0	0	0	0	0	0	0	0	5	5	5	5	5	5	5	5	10	10	10	3.9
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
28	0	0	0	0	0	0	0	0	0	0	0	0	0	33	33	33	33	0	0	7.0
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
30	8	8	8	8	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.0

generated levels were within tolerance. During October, the Pacific high retreats to about 33 °N latitude and the Aleutian Low is firmly entrenched near southwestern Alaska. The Azores-Bermuda high has shifted to the east. The jet stream (main storm track) has moved southward (Bryson and Hare, 1974), crossing the northern Great Lakes and exiting south of Newfoundland (Ludlum, 1982).

Figure 68 shows the October temperature frequency group patterns for North America and Figure 69 shows the same for the islands in the Pacific Ocean. October is comprised of 26 groups. Temperature frequency group patterns for October are quite similar to September. A southwest-northeast orientation persists in the eastern third of the U.S. and a more north-south orientation in the Great Plains and Rockies. Coastal California again is defined by one group (6). Canada's patterns are quite identical to the patterns exhibited during September. However, a new group (15) has appeared over the northern portion of the Canadian Archipelago and northern Greenland -- this is the beginning of a regime of positive skewness along the periphery of the Polar Sea.

The Pacific islands are divided into four groups, and latitude and P/E are the most important variables in determining this breakout.

Figures 70 and 71 show the group mean October skewness for North America and the Pacific islands, respectively. Roughly 61 percent of all the groups possess a positive skew. Areas of high positive skew remain along the California coast and in coastal areas south of Puget Sound. High positive skewness has again returned to the High Arctic. Most of the rest of the northern portions of CONUS also possess a positive skew.

Southern Florida, once again, has a high negative skew. The rest of the southeastern U.S. is again skewed negative. There is a high frequency of anticyclonic activity in the central Appalachian Mountain region especially during October (Klein, 1957). Therefore, prevailing winds at locations to the south of this frequent feature are primarily from the east and northeast. Thus, cooler temperatures and more negatively skewed distributions are dominant. North coastal Alaska and the south-central and southeastern portions of the Canadian Archipelago also are highly negatively skewed .

In the Pacific, Group 4 (the northernmost and southernmost group) has a high negative skew. This is caused by the fact that these two sites, Midway and Pago Pago, are grouped with stations in southern Florida. Midway and Pago Pago have relatively low negative skewness values (-0.05 and -0.06, respectively). Group 21 is comprised of one station, Kwajalein, and possesses an extremely high positive skew (+0.48). The primary variable in discriminating between Group 21 and Group 10 (which surrounds Group 21) is P/E. The reason for the high positive skewness in the midst of negatively skewed, Group 10 stations is an unknown. The data for Kwajalein were rechecked and appear reasonable. However, the data could be in error.

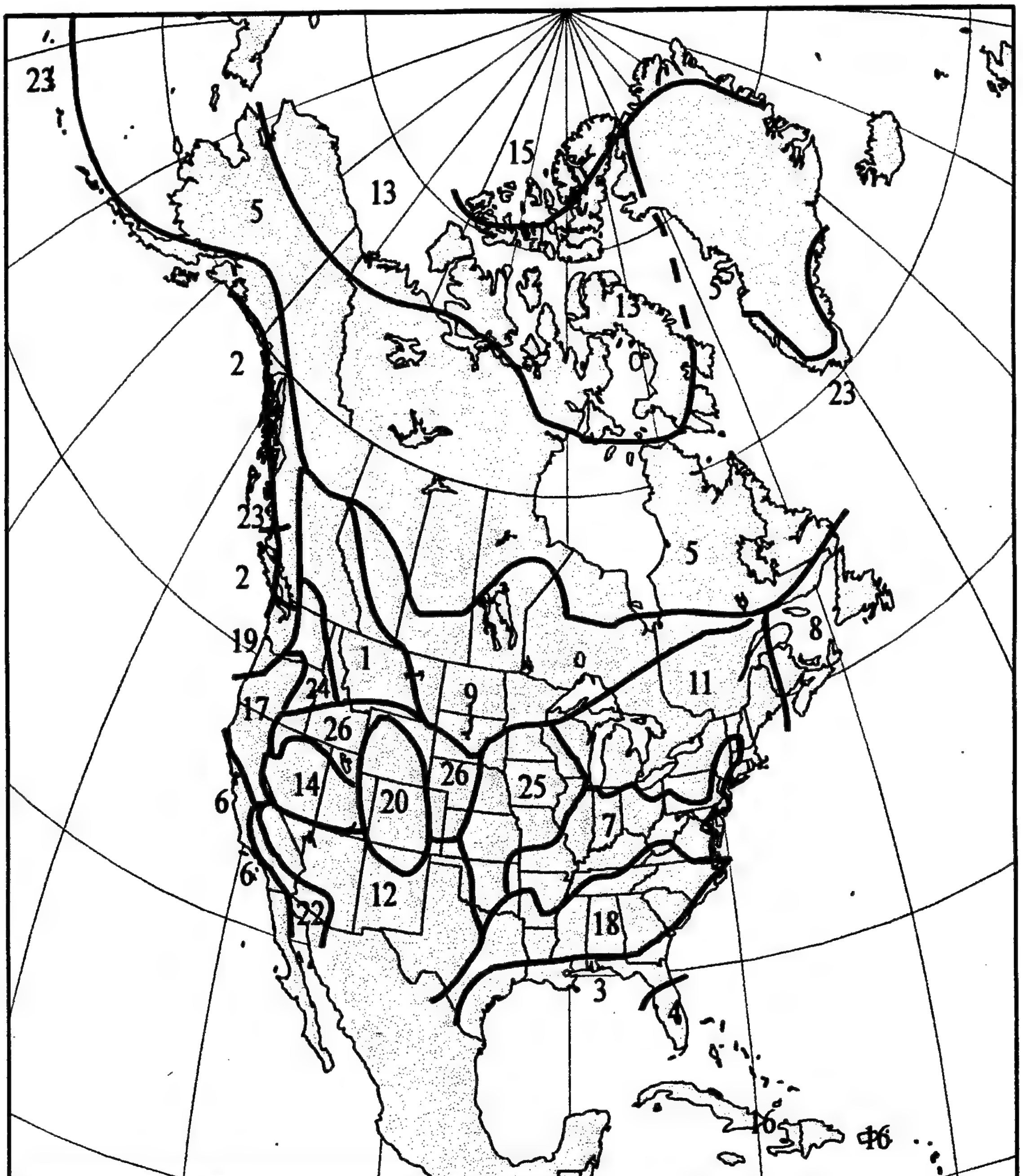

FIGURE 68. NORTH AMERICA TEMPERATURE FREQUENCY GROUPS FOR OCTOBER

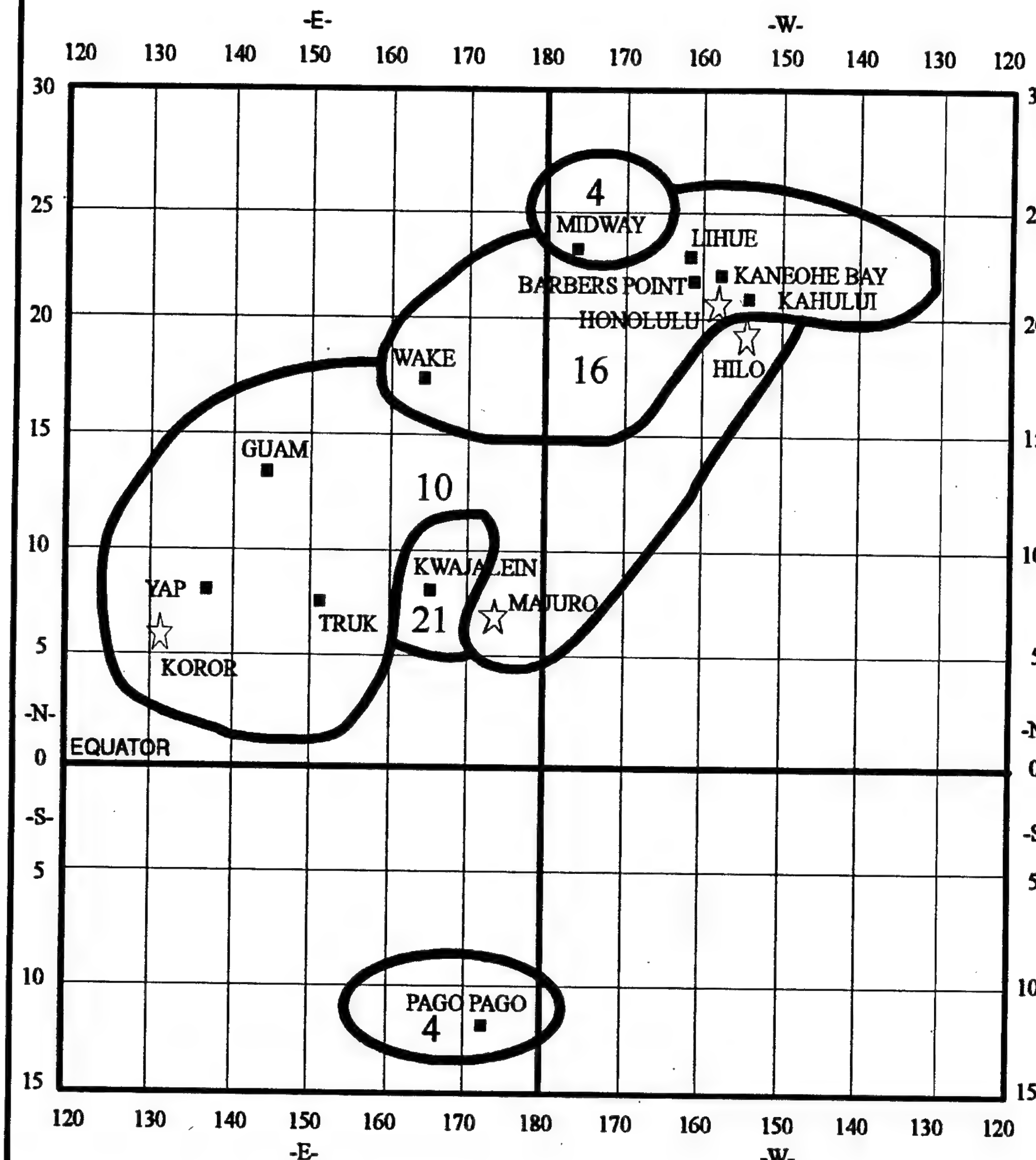

FIGURE 69. PACIFIC ISLANDS TEMPERATURE FREQUENCY GROUPS FOR OCTOBER

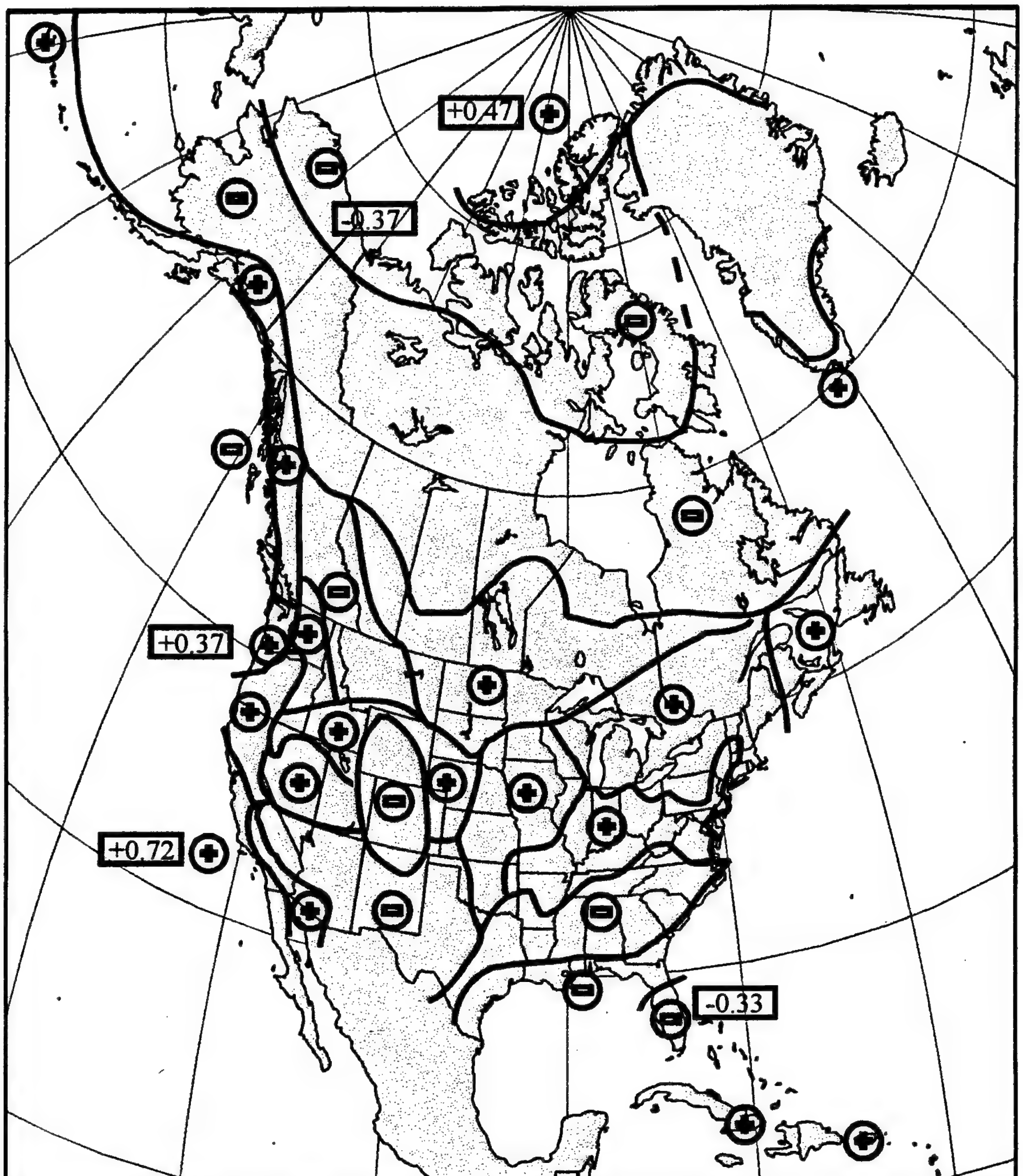

FIGURE 70. NORTH AMERICA TEMPERATURE FREQUENCY GROUP SKEWNESS FOR OCTOBER

⊕ = POSITIVE SKEW ⊖ = NEGATIVE SKEW

▭ = VALUES >/= 0.3 OR </= -0.3

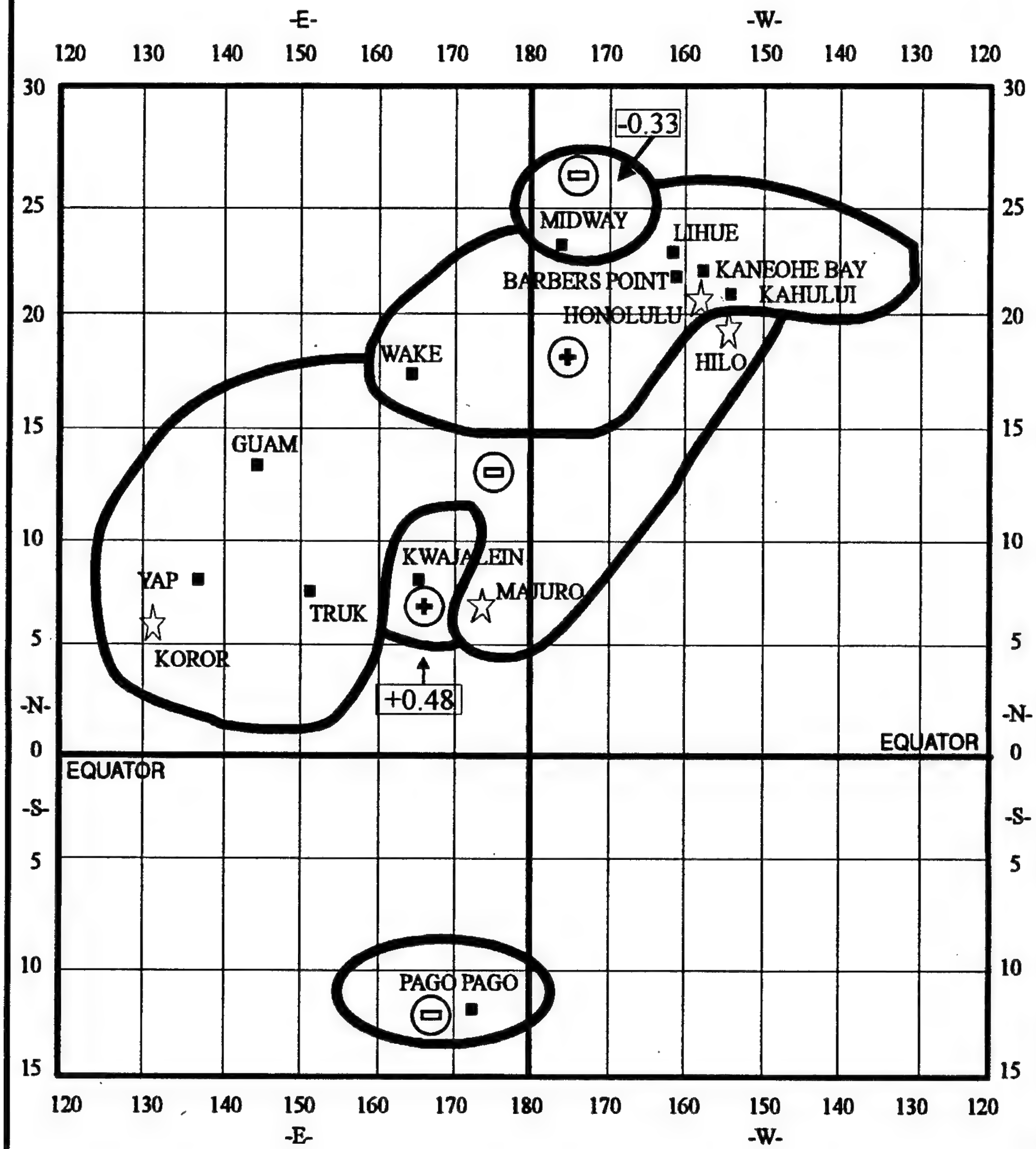

FIGURE 71. PACIFIC ISLANDS TEMPERATURE FREQUENCY GROUP SKEWNESS FOR OCTOBER

(+) = POSITIVE SKEW (−) = NEGATIVE SKEW

▭ = VALUES >/= 0.3 OR </= -0.3

Table 59. Group Means for October

Group	Station Count	Latitude	Elevation	P/E	Continentality	Temperature Range Monthly	Temperature Range Daily	Normalized Mean Daily Max Team	Normalized Mean Daily Min Temp
1	7	48.50	3315	36.6	38.2	90.6	24.1	68.4	41.5
2	2	53.74	104	338.0	11.8	58.0	15.0	65.6	39.8
3	17	30.09	67	75.8	30.5	61.6	20.8	76.3	42.5
4	8	27.17	27	63.8	15.0	45.0	14.0	76.4	45.8
5	7	62.02	366	56.4	41.6	77.3	13.0	62.9	45.9
6	9	34.79	51	21.3	5.8	63.6	16.2	51.2	25.8
7	19	39.57	520	88.5	44.4	72.1	22.2	65.3	34.6
8	7	45.78	261	172.2	31.3	51.4	12.7	59.3	34.6
9	5	47.97	1627	40.0	55.9	88.2	23.2	61.3	35.2
10	4	11.19	76	152.9	-9.6	25.3	11.0	76.2	32.5
11	26	42.21	462	99.0	42.7	67.5	18.7	61.0	33.4
12	9	33.75	2801	17.2	42.1	73.9	27.6	71.7	34.4
13	3	70.53	48	23.7	40.8	67.3	10.0	67.8	52.8
14	3	40.41	4592	21.3	37.0	82.7	38.0	73.3	27.4
15	1	81.60	0	36.1	40.8	69.0	5.0	46.3	39.1
16	6	20.81	45	36.3	-1.4	30.0	12.7	73.5	31.6
17	3	42.49	794	35.0	28.4	74.3	28.7	65.9	27.1
18	23	34.54	644	85.3	37.1	71.0	23.7	70.3	37.0
19	3	46.57	88	118.0	12.1	60.7	18.0	57.5	28.2
20	6	39.45	5507	25.8	43.5	75.3	27.2	70.8	34.5
21	1	8.73	7	127.8	-11.1	26.0	9.0	61.5	26.9
22	4	34.46	512	8.4	36.7	76.0	29.0	72.0	33.9
23	5	57.60	99	104.5	11.3	47.2	8.2	59.0	41.9
24	1	47.63	2356	53.9	34.1	75.0	21.0	62.6	34.6
25	12	41.19	1183	59.4	53.5	79.0	24.0	63.8	33.4
26	7	41.36	3734	29.5	44.9	80.4	30.0	67.8	30.5
ALL	198	39.32	985	72.6	34.1	67.2	20.5	66.6	35.9

Table 60. Group Mean Normalized Temperatures: October

	Frequency Levels																				
Group	0	0.001	0.005	0.01	0.03	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	0.95	0.97	0.99	0.995	0.999	1.0
1	0	9.80	19.83	24.39	30.82	33.58	37.35	42.27	46.25	49.69	52.93	56.25	59.85	64.30	70.97	76.54	79.84	85.77	88.64	93.06	100
2	0	10.10	16.82	20.12	25.91	29.02	33.99	40.46	45.20	48.93	51.97	54.87	57.72	60.78	65.07	69.16	72.43	78.37	81.92	89.50	100
3	0	7.16	14.06	17.66	24.53	28.53	35.10	43.71	49.67	54.39	58.47	62.29	66.20	70.72	76.78	80.94	83.31	87.35	89.32	93.15	100
4	0	9.72	17.15	21.74	29.90	33.82	39.82	46.46	50.64	54.02	57.08	60.29	63.98	68.34	73.83	77.60	79.53	83.46	85.33	88.96	100
5	0	7.04	13.65	17.79	25.56	29.83	36.35	42.90	47.78	51.72	54.99	58.19	61.18	64.69	69.09	73.09	75.48	80.21	82.98	91.22	100
6	0	7.77	12.85	15.25	18.92	20.85	23.74	27.30	29.93	32.24	34.53	36.99	39.81	43.27	48.73	54.29	58.73	68.37	73.84	83.01	100
7	0	5.61	10.71	13.53	19.10	22.23	27.48	34.26	39.34	43.78	48.04	52.30	56.75	61.80	68.77	74.49	78.11	84.34	87.22	92.44	100
8	0	5.18	10.12	12.58	17.60	20.72	25.73	32.33	37.35	41.58	45.18	48.67	52.64	57.57	64.56	70.39	74.10	79.43	82.35	88.75	100
9	0	8.39	15.27	19.02	24.47	27.10	30.72	35.60	39.43	42.78	46.05	49.43	53.01	57.80	65.02	70.83	74.27	80.82	84.41	90.54	100
10	0	12.59	19.01	21.99	25.66	28.91	33.08	38.29	42.38	45.64	48.94	52.82	57.70	63.52	69.33	74.02	76.06	79.10	81.12	85.34	100
11	0	5.13	10.33	12.95	18.04	21.06	25.95	32.24	37.02	41.16	44.96	48.93	53.26	58.27	65.25	70.94	74.49	81.25	84.68	90.75	100
12	0	8.72	14.52	17.43	22.84	25.92	30.91	37.32	42.13	46.43	50.68	55.13	60.09	65.97	73.42	78.66	81.55	86.39	88.73	93.05	100
13	0	8.15	13.71	17.18	25.77	29.55	36.77	45.41	51.90	57.34	61.46	65.62	69.55	74.65	79.09	82.30	84.61	88.03	89.75	93.02	100
14	0	7.98	12.05	14.52	19.40	21.95	26.37	32.22	37.21	41.85	46.68	52.01	58.20	65.50	74.29	80.57	83.87	88.65	90.97	94.35	100
15	0	5.29	8.81	10.57	15.31	18.39	21.95	27.67	31.54	35.04	39.03	43.24	47.21	51.83	57.44	64.60	69.17	88.39	92.74	96.66	100
16	0	8.97	15.48	18.42	23.57	26.48	31.09	36.35	40.32	43.66	47.33	51.49	56.49	61.72	67.84	72.62	75.06	79.91	82.65	87.19	100
17	0	7.38	11.65	13.89	18.18	20.61	24.57	29.67	33.74	37.39	41.13	45.28	50.03	56.02	64.25	70.85	74.88	82.18	85.60	91.60	100
18	0	6.58	11.84	14.81	20.67	24.15	29.94	37.61	43.16	47.79	51.02	56.04	60.16	64.92	71.64	76.67	79.48	84.04	86.42	91.51	100
19	0	5.58	10.94	13.21	17.65	20.33	24.81	30.90	34.52	37.79	40.81	43.70	46.70	50.26	56.05	61.41	65.44	72.85	77.34	86.50	100
20	0	8.04	13.64	16.96	23.03	26.18	30.78	36.79	41.40	45.52	49.62	54.07	59.30	65.80	73.95	79.58	82.48	87.06	89.21	93.03	100
21	0	4.66	9.84	12.99	17.63	20.40	24.45	28.93	32.19	34.59	37.00	39.94	43.68	48.01	53.49	58.19	60.19	65.33	68.23	75.14	100
22	0	11.19	17.86	20.57	25.50	28.12	32.37	37.66	41.94	45.91	49.86	54.17	59.10	64.83	72.01	77.33	80.47	85.36	87.88	92.25	100
23	0	9.75	16.11	19.77	26.08	28.93	33.76	39.49	43.12	46.42	49.58	52.42	55.60	59.51	65.24	69.97	72.91	79.17	81.83	88.01	100
24	0	7.81	15.85	19.07	23.50	25.99	29.94	35.25	39.15	42.50	45.65	48.83	52.37	56.88	64.13	70.12	74.50	82.59	85.92	91.34	100
25	0	6.40	11.90	14.87	19.84	22.64	27.20	33.50	38.29	42.45	46.47	50.62	55.13	60.40	67.52	73.32	76.88	83.23	86.22	92.17	100
26	0	8.74	13.46	15.83	20.77	23.47	27.78	33.53	38.07	42.16	46.41	50.88	56.00	62.44	70.93	77.17	80.68	86.46	89.18	93.07	100

Table 61. Discriminant Function Values: October

Function value = (a x lat) + (b x elev) + (c x P/E) + (d x K) + (e x mrange) + (f x drange) + (g x nmax) + (h x nmin) + constant

Group	a	b	c	d	e	f	g	h	constant
1	12.779	0.015	-0.344	-0.338	14.367	-52.581	45.886	-35.585	-1171.16
2	13.243	-0.002	0.484	-1.987	14.689	-55.162	46.788	-37.760	-1224.58
3	10.871	-0.006	-0.293	-0.150	13.324	-52.122	46.371	-35.636	-1033.37
4	10.965	-0.005	-0.362	-1.082	13.465	-54.861	47.985	-36.802	-1041.72
5	15.399	-0.006	-0.425	-0.108	14.850	-57.768	49.421	-38.344	-1337.95
6	10.801	-0.004	-0.315	-2.010	14.136	-52.996	44.144	-36.401	-862.91
7	11.248	-0.004	-0.199	0.621	13.242	-50.167	43.989	-34.683	-988.47
8	12.050	-0.004	0.015	-0.249	13.450	-53.005	44.944	-36.070	-992.57
9	12.103	0.003	-0.319	1.125	13.754	-50.773	43.992	-34.698	-1077.37
10	8.988	0.001	0.007	-2.790	18.694	-75.709	60.736	-51.368	-1364.91
11	11.469	-0.003	-0.164	0.494	13.513	-51.709	44.398	-35.456	-982.37
12	10.845	0.011	-0.398	0.443	12.590	-47.792	43.489	-33.506	-997.24
13	17.798	-0.011	-0.670	-0.192	13.545	-55.788	49.937	-36.953	-1513.32
14	12.079	0.021	-0.394	-0.183	10.958	-39.840	39.889	-29.984	-1036.06
15	18.293	-0.010	-0.542	-0.393	14.519	-58.335	49.170	-38.749	-1467.63
16	11.155	-0.004	-0.423	-2.328	17.006	-70.489	58.712	-48.355	-1316.35
17	12.802	-0.004	-0.395	-0.687	12.763	-48.077	44.443	-34.885	-1034.09
18	10.825	-0.002	-0.212	0.175	13.156	-49.747	44.165	-34.435	-978.57
19	12.952	-0.005	-0.133	-1.819	14.033	-53.563	46.150	-37.493	-1028.17
20	11.348	0.030	-0.347	0.281	13.108	-49.597	44.358	-34.434	-1106.89
21	7.167	0.001	0.042	-2.588	16.131	-64.134	50.709	-43.277	-949.91
22	11.526	-0.006	-0.473	0.120	12.120	-45.814	42.973	-32.727	-989.58
23	15.052	-0.007	-0.309	-1.830	12.320	-50.239	44.354	-33.818	-1093.10
24	12.725	0.009	-0.306	-0.422	13.861	-52.371	45.524	-35.971	-1073.66
25	11.209	0.000	-0.264	1.187	13.060	-48.910	43.039	-33.861	-994.82
26	11.651	0.017	-0.347	0.422	12.352	-45.822	42.167	-32.648	-1020.42

INPUT VARIABLES

lat = latitude
elev = elevation
P/E = Precipitation Effectiveness Index
K = Continentality
mrange = monthly temperature range
drange = daily temperature range
nmax = normalized mean daily maximum temperature
nmin = normalized mean daily minimum temperature

Table 62. Temperature Frequency Equations: October

Group	If Input Normalized Temperature (T) < 50th Percentile Normalized Temperature (T)	Maximum Error E1	Maximum Error E2	50th Percentile Normalized T	Group	If Input Normalized Temperature (T) > 50th Percentile Normalized Temperature (T)	Maximum Error E3	Maximum Error E4
1	F=0.0003+0.002372*T-0.000285326*T^2+7.98468e-006*T^3	0.007	0.010	52.93	1	F=-4.5383+0.173128*T-0.00180638*T^2+6.28935e-006*T^3	0.004	0.008
2	F=0.0001+0.0010117*T-0.000149436*T^2+6.05898e-006*T^3	0.001	0.002	51.97	2	F=-7.2132+0.284673*T-0.00327488*T^2+1.24962e-005*T^3	0.012	0.007
3	F=0.0004+4.10322e-006*T-1.92082e-005*T^2+2.82972e-006*T^3	0.006	0.007	58.47	3	F=-3.6571+0.117798*T-0.000923953*T^2+2.11273e-006*T^3	0.006	0.007
4	F=-0.0038+0.00353453*T-0.000283973*T^2+6.58734e-006*T^3	0.008	0.007	57.08	4	F=-4.9593+0.171766*T-0.00161842*T^2+4.96446e-006*T^3	0.005	0.009
5	F=-0.0018+0.00182858*T-0.000167528*T^2+5.45969e-006*T^3	0.003	0.005	54.99	5	F=-7.1800+0.267413*T-0.00290351*T^2+1.04717e-005*T^3	0.013	0.005
6	F=0.0014+0.0020669*T-0.000487362*T^2+2.47517e-005*T^3	0.005	0.010	34.53	6	F=-4.4488+0.283664*T-0.00553081*T^2+4.76839e-005*T^3-1.52936e-007*T^4	0.003	0.003
7	F=0.0045-0.00232688*T+0.000155758*T^2+2.29562e-006*T^3	0.004	0.006	48.04	7	F=-2.4824+0.101933*T-0.000982016*T^2+3.1061e-006*T^3	0.007	0.003
8	F=0.0027-0.0017098*T+0.000131831*T^2+3.33491e-006*T^3	0.003	0.003	45.18	8	F=-2.7745+0.122651*T-0.00132762*T^2+4.78542e-006*T^3	0.001	0.001
9	F=0.0030+5.33074e-005*T-0.000154859*T^2+8.55078e-006*T^3	0.006	0.011	46.05	9	F=-3.1527+0.137119*T-0.00151097*T^2+5.5516e-006*T^3	0.003	0.001
10	F=0.0016+0.00068142*T-0.000181924*T^2+7.76096e-006*T^3	0.004	0.009	48.94	10	F=-1.8731+0.0725273*T-0.000543309*T^2+1.05107e-006*T^3	0.011	0.013
11	F=0.0040-0.0022267*T+0.000152222*T^2+3.23368e-006*T^3	0.004	0.005	44.96	11	F=-2.4309+0.107603*T-0.00112077*T^2+3.87636e-006*T^3	0.006	0.001
12	F=0.0044-0.0021047*T+7.791e-005*T^2+3.16441e-006*T^3	0.006	0.009	50.68	12	F=-1.7501+0.0658732*T-0.000466512*T^2+8.24564e-007*T^3	0.002	0.005
13	F=0.0010-0.000213552*T-1.15093e-006*T^2+2.22115e-006*T^3	0.002	0.003	61.46	13	F=21.1814-1.13372*T+0.0222808*T^2-0.000186298*T^3+5.66798e-007*T^4	0.005	0.006
14	F=0.0073-0.0049221*T+0.000334443*T^2+3.90529e-008*T^3	0.010	0.010	46.68	14	F=-0.7162+0.0319544*T-0.000106977*T^2-4.10842e-007*T^3	0.001	0.002
15	F=0.0062-0.00386777*T+0.000320193*T^2+2.83081e-006*T^3	0.010	0.010	39.03	15	F=-2.0980+0.107332*T-0.00123732*T^2+4.73878e-006*T^3	0.011	0.004
16	F=0.0027-0.000314949*T-9.75062e-005*T^2+7.0103e-006*T^3	0.003	0.013	47.33	16	F=-2.0715+0.084966*T-0.000746987*T^2+2.0408e-006*T^3	0.012	0.010
17	F=0.0055-0.00380255*T+0.000230673*T^2+3.90116e-006*T^3	0.009	0.010	41.13	17	F=-1.6035+0.0801082*T-0.000820274*T^2+2.7946e-006*T^3	0.001	0.001
18	F=0.0002-0.000201546*T+6.07658e-006*T^2+3.68853e-006*T^3	0.001	0.007	51.02	18	F=4.1011-0.273293*T+0.00670935*T^2-6.48937e-005*T^3+2.20292e-007*T^4	0.006	0.003
19	F=0.0009-0.000255825*T-4.2701e-005*T^2+8.60558e-006*T^3	0.001	0.006	40.81	19	F=-5.2911+0.287969*T-0.00493688*T^2+3.75246e-005*T^3-1.06612e-007*T^4	0.008	0.001
20	F=0.0047-0.00182356*T+4.62923e-005*T^2+3.95413e-006*T^3	0.005	0.011	49.62	20	F=-1.4556+0.0570295*T-0.0003841*T^2+5.92304e-007*T^3	0.002	0.003
21	F=-0.0013+0.0024823*T-0.000367701*T^2+1.80923e-005*T^3	0.003	0.006	37.00	21	F=-2.3607+0.126701*T-0.00157467*T^2+6.437e-006*T^3	0.005	0.005
22	F=0.0044-0.00186751*T+3.03758e-006*T^2+4.79977e-006*T^3	0.010	0.014	49.86	22	F=-1.9315+0.074893*T-0.000594108*T^2+1.3798e-006*T^3	0.004	0.005
23	F=-0.0002+0.00210059*T-0.000256472*T^2+8.47709e-006*T^3	0.003	0.006	49.58	23	F=-5.0655+0.206662*T-0.00234202*T^2+8.82036e-006*T^3	0.002	0.003
24	F=0.0026-0.000291406*T-0.000118981*T^2+8.06017e-006*T^3	0.006	0.008	45.65	24	F=-3.2973+0.145096*T-0.00163648*T^2+6.15542e-006*T^3	0.006	0.005
25	F=0.0050-0.00279758*T+0.000160178*T^2+2.85598e-006*T^3	0.006	0.007	46.47	25	F=-2.3079+0.0985477*T-0.000969198*T^2+3.14238e-006*T^3	0.005	0.003
26	F=0.0055-0.00346263*T+0.000182557*T^2+2.7346e-006*T^3	0.009	0.011	46.41	26	F=-1.5575+0.0676794*T-0.000574636*T^2+1.53452e-006*T^3	0.001	0.002

E1 = Maximum Prediction Error When Computed Frequency < 5%
E2 = Maximum Prediction Error When Computed Frequency Between 5 - 50%
E3 = Maximum Prediction Error When Computed Frequency Between 50 - 95%
E4 = Maximum Prediction Error When Computed Frequency >95%

Table 63. Percent Probability of Predicted Temperatures >2.0C at Each Frequency Level by Group

Month: October

GROUP	STANDARDIZED FREQUENCY LEVELS																			% OF ALL >
	0.001	0.005	0.01	0.03	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	0.95	0.97	0.99	0.995	0.999	2.0C
1	28	14	0	0	0	0	0	0	0	14	14	14	14	14	0	0	0	0	0	6.0
2	0	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	0	0	0	39.5
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
5	0	0	0	0	14	28	28	28	14	14	14	14	14	14	14	14	14	14	14	6.4
6	0	0	0	0	0	11	11	11	11	11	11	11	0	0	0	0	0	0	11	4.7
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5	5	5	5	1.4
8	0	14	14	14	0	14	14	0	0	0	0	0	0	0	0	0	0	0	0	3.8
9	5	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	2.2
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
11	0	0	0	4	4	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0.8
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
13	0	33	33	0	0	0	33	33	33	33	33	0	0	0	0	0	0	0	0	12.3
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
16	0	0	0	0	0	0	16	16	16	0	0	0	0	0	0	0	0	0	0	2.6
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
18	0	4	4	4	4	4	0	0	0	0	0	0	0	0	0	0	0	4	0	1.4
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
20	17	34	34	34	34	17	0	0	0	0	0	0	0	0	0	0	0	0	0	5.3
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
23	0	0	0	20	20	20	20	20	20	20	20	20	20	0	20	0	0	0	0	11.6
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0.4
26	14	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.5

October group means for the attribute variables appear in Table 59, group mean normalized temperatures in Table 60, discriminant functions in Table 61, curve-fitting equations in Table 62, and percent probabilities by frequency level in Table 63.

<u>November</u> -- Model performance in November decreased from October's levels. About 68 percent of all the stations had no errors and about 90 percent of all generated levels were within the +/-2.0°C tolerance. During November the majority of circulation patterns takes on typical wintertime characteristics (Klein, 1957). The Pacific high retreats further to the south off the coast of northern Mexico and is reduced in strength to its winter normal. Storms can now move across the Pacific without hindrance and strike the coast of California and northward. The Aleutian low moves into the northwest corner of the Gulf of Alaska and the high over the Great Basin strengthens and becomes an important wintertime feature (Ludlum, 1982). The Azores-Bermuda high stays in relatively the October position, but weakens its presence over the U.S. mainland, thus allowing coastal storms to sweep northward over the Atlantic seaboard.

Figure 72 shows the November temperature frequency group patterns for North America and Figure 73 shows the same for the islands in the Pacific Ocean. November is comprised of 30 groups. November's patterns more closely resemble those of December (Figure 24) than they do the patterns of October (Figure 68). The plunge of Group 8 in northern Canada resembles December's Group 21 and approximates the location of the Arctic tree-line (Dfc and ET climate boundary). Patterns in the southeastern U.S. regain their southwest to northeast orientation. The western portions of Group 9 define the approximate location of the U.S. steppe. Coastal California (Group 7) is again separated from the Channel Islands (Group 21), with monthly temperature range being an important variable in this separation. The Pacific Coast, north of about 45°N latitude, represents the region of Marine West Coast (Cfb) climate type. The Pacific island groupings are along a north-south axis, with latitude and P/E being the two important variables.

Figures 74 and 75 show the group mean November skewness for North America and the Pacific islands, respectively. Whereas more groups were positively skewed in the two previous autumn months, more are negatively skewed during November (63 percent). Areas of high positive skewness persist in California as the region still benefits from the presence of the Pacific high. Northward, the Pacific coast of CONUS, Canada and Alaska exhibits a high negative skew, showing the effects of the mP air mass invasion triggered by the Aleutian low. The High Arctic remains positive and its southern boundary coincides quite nicely with the southern boundary of the "Arid" Humidity Province in the High Arctic (Figure 10). High negative skewness also persists in central and southern Florida with prevailing winds being easterly and northeasterly. The steppe region is slightly positive, probably reflecting the southerly wind flow prevalent at the time. The East Coast of the U.S. is slightly negative.

November group means for the attribute variables appear in Table 64, group mean

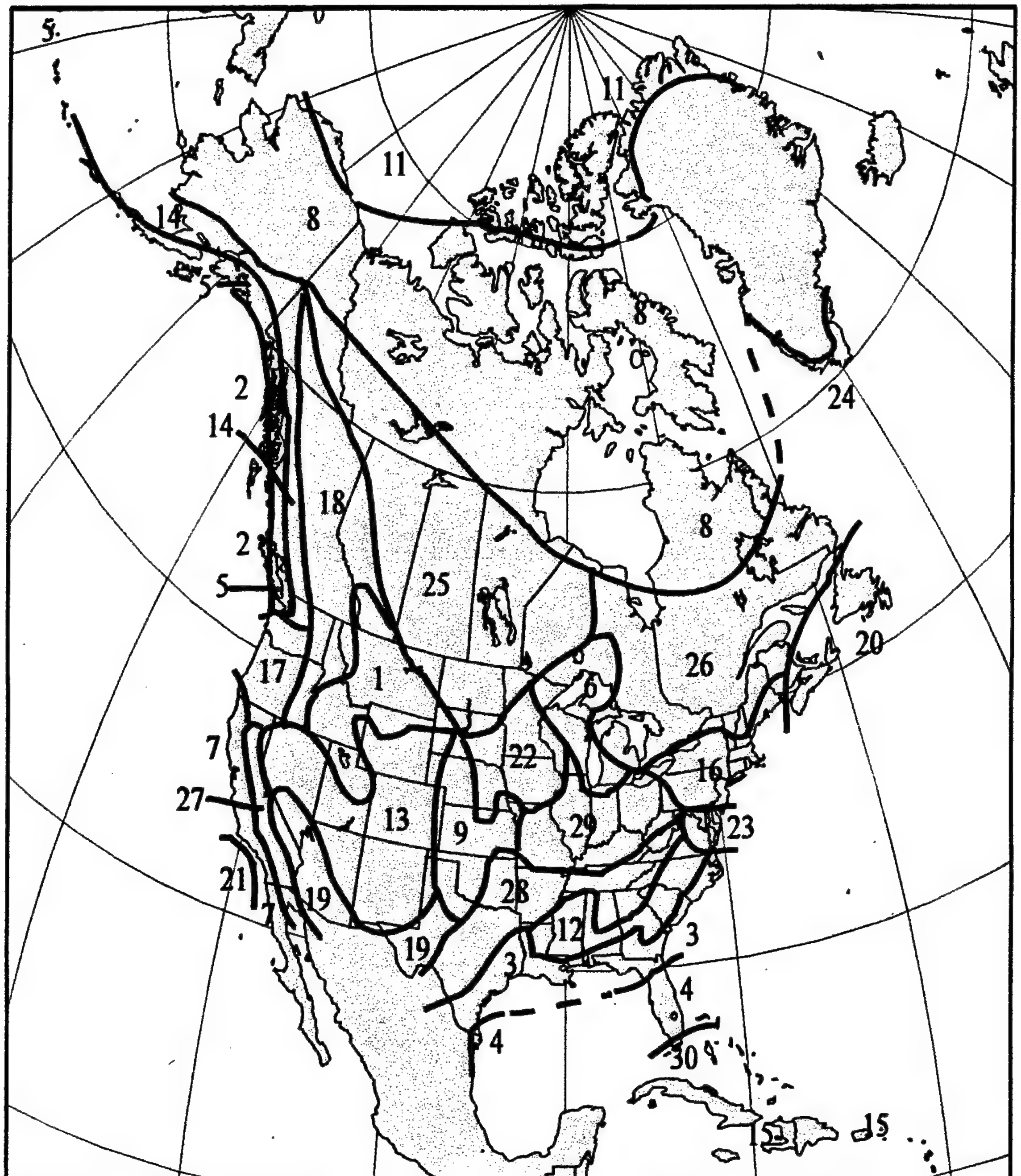

FIGURE 72. NORTH AMERICA TEMPERATURE FREQUENCY GROUPS FOR NOVEMBER

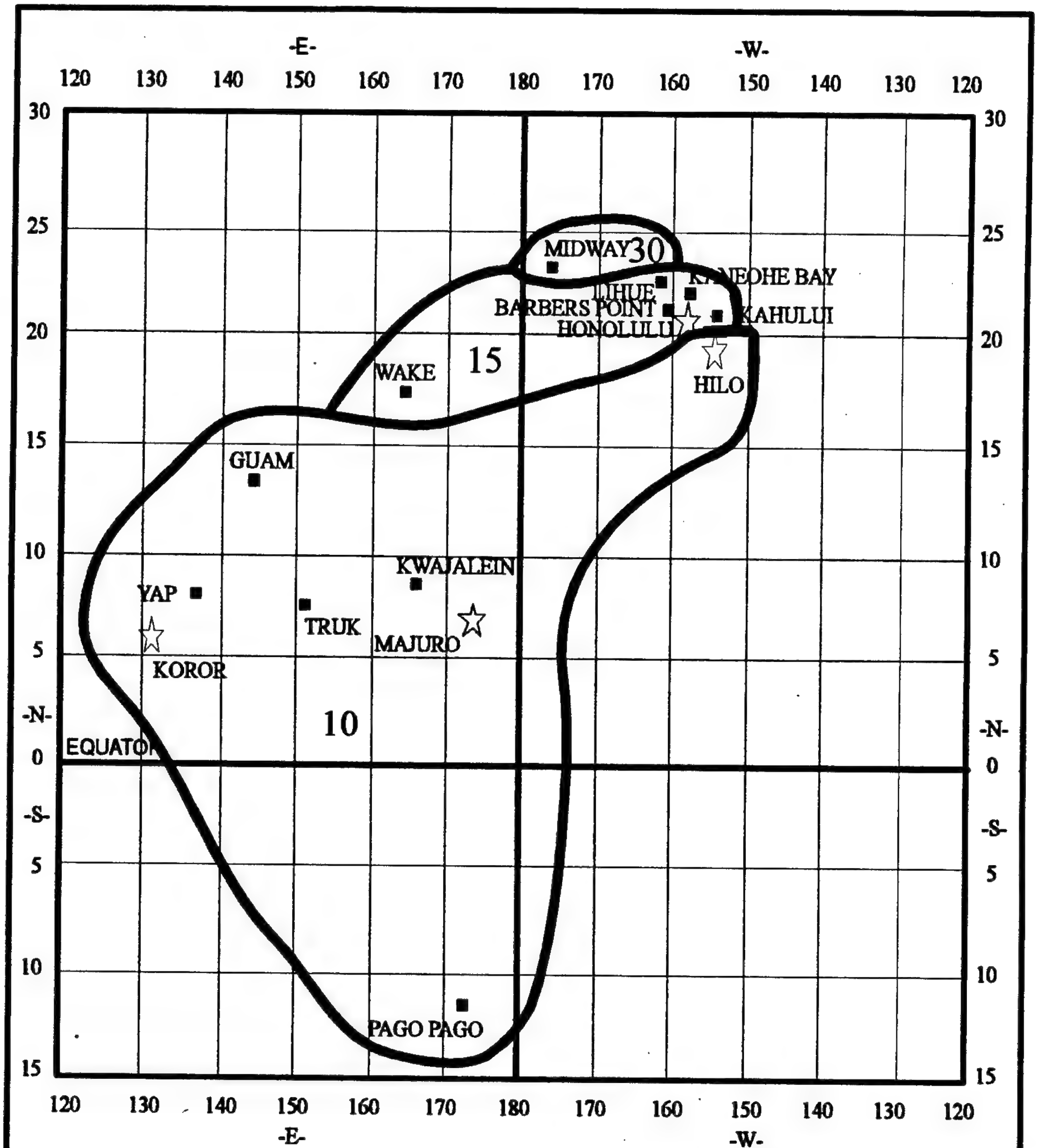

FIGURE 73. PACIFIC ISLANDS TEMPERATURE FREQUENCY GROUPS FOR NOVEMBER (Pacific Islands)

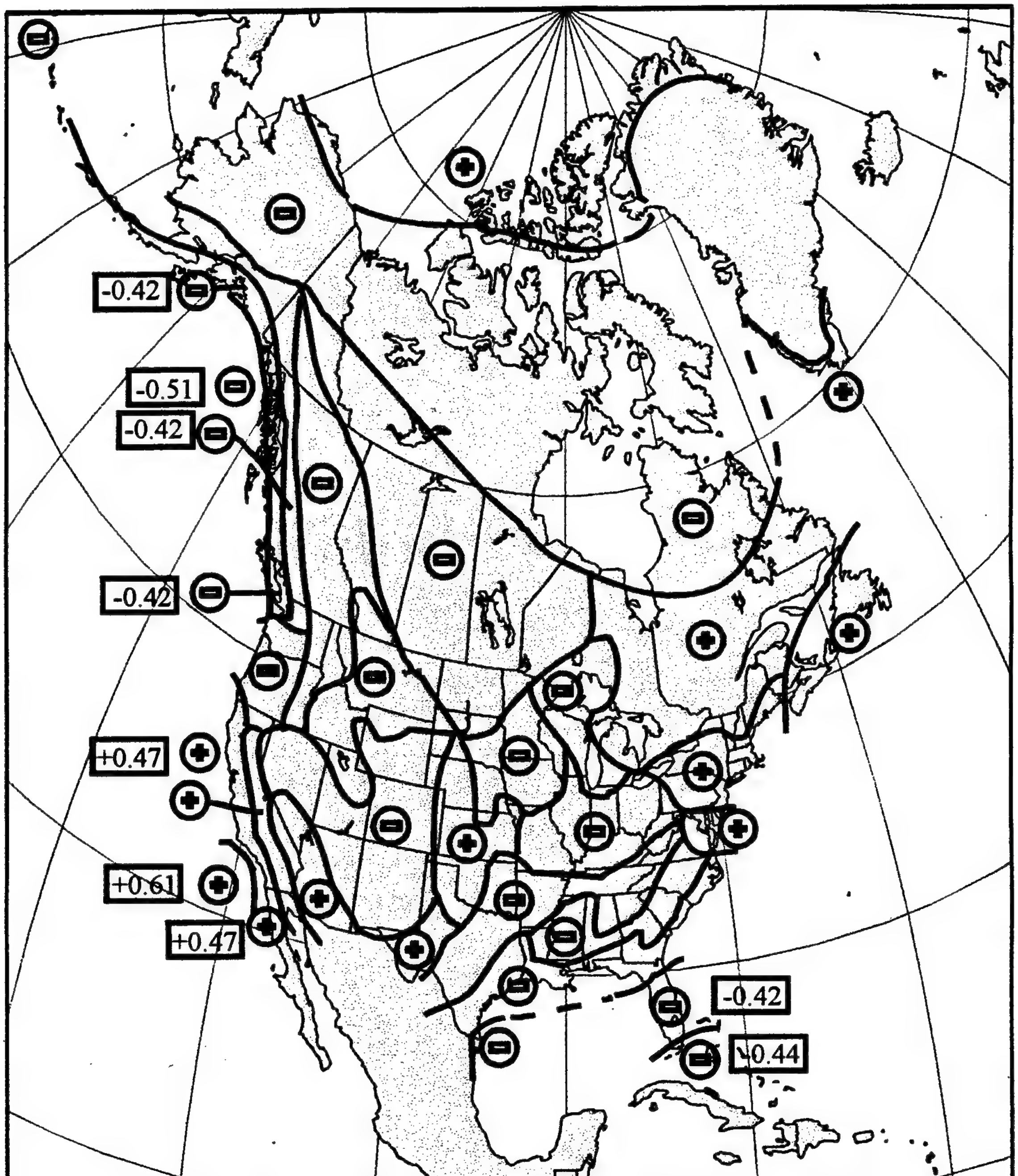

FIGURE 74. NORTH AMERICA TEMPERATURE FREQUENCY GROUP SKEWNESS FOR NOVEMBER

(+) = POSITIVE SKEW (−) = NEGATIVE SKEW

[ ] = VALUES >/= 0.3 OR VALUES </= -0.3

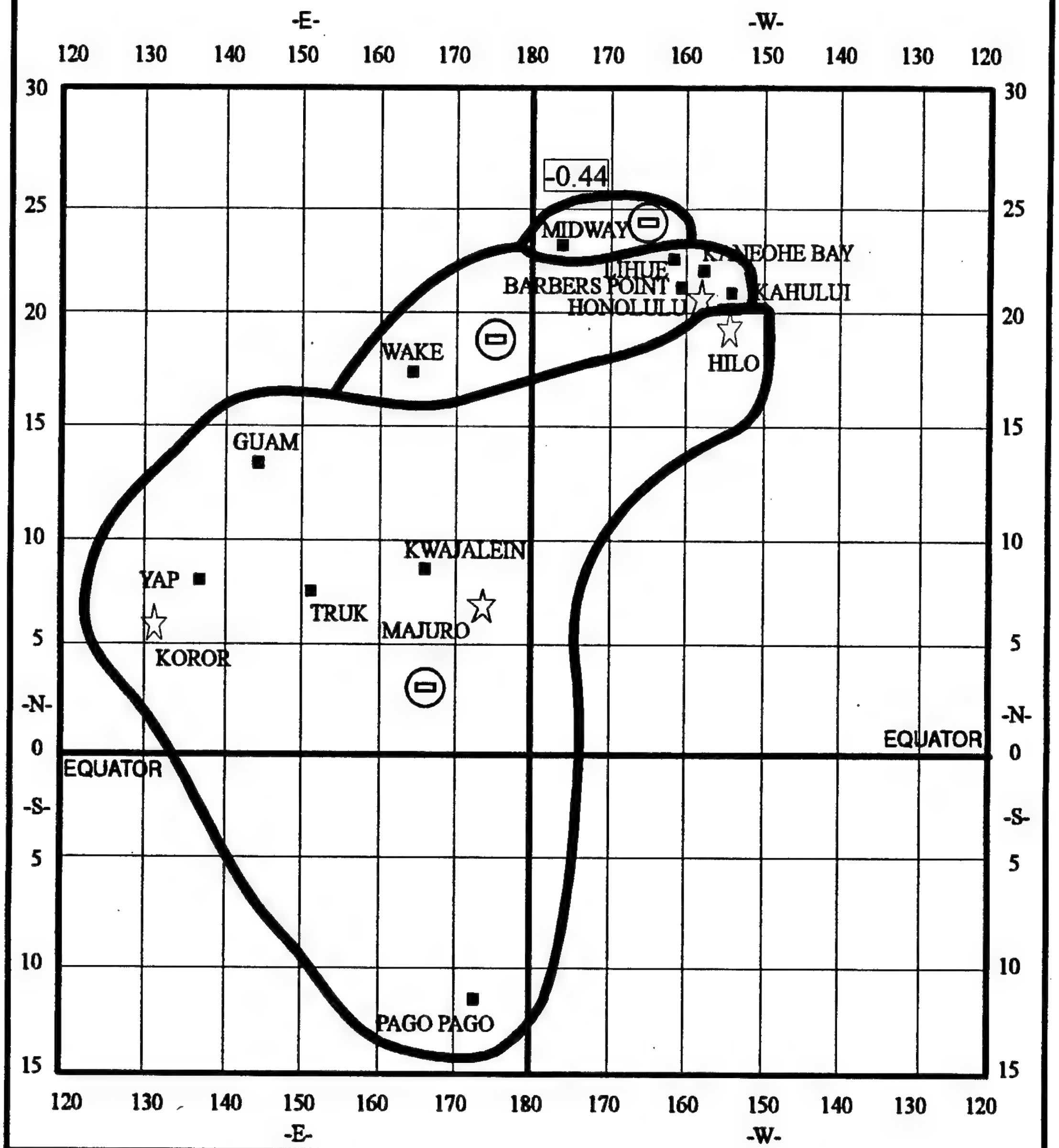

FIGURE 75. PACIFIC ISLANDS TEMPERATURE FREQUENCY GROUP SKEWNESS FOR NOVEMBER

(+) = POSITIVE SKEW (-) = NEGATIVE SKEW

[ ] = VALUES >/= 0.3 OR </= -0.3

Table 64. Group Means for November

Group	Station Count	Latitude	Elevation	P/E	Continentality	Temperature Range Monthly	Temperature Range Daily	Normalized Mean Daily Max Team	Normalized Mean Daily Min Temp
1	7	45.53	3788	33.4	41.7	97.1	20.4	68.9	47.7
2	2	53.74	104	338.0	11.8	64.5	13.0	72.8	52.7
3	21	30.79	125	78.6	32.0	69.0	21.8	73.4	41.7
4	6	28.18	33	66.5	19.5	61.5	19.0	78.6	47.7
5	2	47.67	8	168.8	10.6	56.0	11.5	70.5	50.0
6	4	42.92	851	84.7	46.4	91.0	15.0	63.7	47.2
7	6	34.94	40	22.4	6.3	61.3	18.8	56.6	25.9
8	6	64.32	413	46.8	43.9	84.0	13.7	62.2	45.8
9	4	38.84	1493	51.5	51.6	86.8	22.5	62.2	36.3
10	5	10.70	62	147.9	-9.9	23.0	10.0	75.7	32.1
11	3	76.48	10	19.8	39.1	73.0	9.7	53.4	40.0
12	7	34.31	281	90.5	36.2	73.9	24.6	69.8	36.5
13	16	38.66	4498	23.5	42.3	85.2	27.1	69.8	37.9
14	4	50.56	305	49.6	19.1	70.8	14.3	70.0	49.9
15	6	20.81	45	36.3	-1.4	32.0	12.2	74.6	36.9
16	15	76.48	10	19.8	39.1	73.0	9.7	53.4	40.0
17	2	34.31	281	90.5	36.2	73.9	24.6	69.8	36.5
18	4	38.66	4498	23.5	42.3	85.2	27.1	69.8	37.9
19	6	50.56	305	49.6	19.1	70.8	14.3	70.0	49.9
20	7	20.81	45	36.3	-1.4	32.0	12.2	74.6	36.9
21	3	34.50	73	19.1	4.8	50.3	12.7	51.7	26.5
22	6	41.72	1280	54.9	54.6	91.0	20.7	64.4	41.7
23	6	38.16	86	85.5	38.2	69.0	19.3	61.9	33.8
24	3	63.50	147	106.4	12.0	54.3	6.3	50.2	38.6
25	5	47.97	1627	40.0	55.9	102.2	19.0	63.4	44.7
26	6	46.45	377	102.1	46.7	72.0	12.8	59.6	41.7
27	4	35.73	239	15.0	32.7	63.8	23.8	64.8	27.7
28	13	35.56	1020	80.8	39.7	75.8	21.5	68.3	39.8
29	16	40.63	728	87.5	46.5	82.4	17.4	63.3	42.1
30	3	26.18	15	58.4	9.5	41.0	10.0	74.4	50.5
ALL	198	39.32	985	72.6	34.1	72.2	18.5	66.2	39.9

Table 65. Group Mean Normalized Temperatures: November

Group	Frequency Levels																				
	0	0.001	0.005	0.01	0.03	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	0.95	0.97	0.99	0.995	0.999	1.0
1	0	8.99	16.55	20.66	28.43	32.75	39.27	46.61	51.06	54.44	57.50	60.71	64.09	68.12	73.73	78.26	81.15	86.30	88.87	92.76	100
2	0	12.11	21.47	25.34	33.02	37.36	43.95	51.34	56.19	59.91	62.79	65.41	68.24	71.50	75.69	78.63	80.56	84.26	86.71	91.42	100
3	0	7.59	14.13	17.40	23.48	26.89	32.88	40.79	46.90	52.17	57.10	61.84	66.39	71.07	76.86	81.19	83.61	87.47	89.26	93.11	100
4	0	8.95	16.24	19.99	27.85	32.40	39.66	48.39	54.21	58.60	62.32	65.75	69.42	73.73	79.05	82.74	84.67	88.10	89.97	92.77	100
5	0	4.93	13.77	19.16	30.24	33.39	40.49	48.19	53.32	56.92	59.97	62.31	64.58	67.64	71.97	75.41	77.76	82.69	85.29	93.08	100
6	0	14.16	23.54	27.30	33.45	36.38	40.54	45.33	48.50	51.29	54.03	56.74	60.08	64.60	71.28	76.09	78.75	83.31	85.94	90.92	100
7	0	6.37	10.65	12.88	16.98	19.43	23.52	28.69	32.35	35.48	38.31	41.08	44.16	47.86	53.97	59.85	63.91	71.78	75.91	83.62	100
8	0	3.45	8.12	11.13	17.41	21.49	28.11	36.51	43.52	49.29	54.11	58.62	63.52	68.86	75.12	79.81	82.54	86.64	89.57	94.35	100
9	0	5.52	11.61	15.10	21.66	25.14	29.86	35.38	39.34	42.97	46.65	50.55	54.79	60.20	67.29	72.68	76.04	81.39	83.86	89.03	100
10	0	16.12	21.78	24.99	29.88	32.73	36.64	42.24	46.25	49.30	52.40	56.02	60.50	65.53	71.17	75.31	77.75	81.11	83.14	88.68	100
11	0	3.96	9.58	12.58	17.52	19.87	24.28	30.87	34.97	39.73	44.05	48.46	53.52	57.92	66.04	71.86	76.29	83.44	87.44	93.91	100
12	0	5.31	11.56	14.43	19.47	22.48	28.01	35.81	41.67	46.75	51.59	56.55	61.52	66.82	73.40	78.33	81.14	85.75	87.99	92.13	100
13	0	8.28	15.76	19.38	25.44	28.79	33.75	39.66	44.02	47.82	51.50	55.37	59.70	64.99	72.33	77.83	81.00	86.31	88.73	92.83	100
14	0	7.99	18.35	23.11	30.89	34.78	40.50	47.47	52.59	56.67	60.41	63.67	66.47	69.70	74.10	77.67	79.98	84.02	86.23	90.58	100
15	0	9.69	17.48	20.90	26.76	29.68	34.37	39.66	43.63	46.84	50.19	53.86	58.28	63.16	69.21	73.71	76.22	80.59	83.24	87.08	100
16	0	6.14	11.62	14.64	20.26	23.26	27.69	32.89	36.85	40.54	44.18	47.90	52.03	56.96	63.84	69.32	72.80	78.94	82.21	88.89	100
17	0	9.31	15.74	19.76	26.48	29.85	34.92	41.28	45.77	49.31	52.63	55.83	59.12	62.96	68.43	73.12	76.30	82.25	85.27	91.04	100
18	0	15.81	25.12	30.38	39.32	43.26	48.81	54.25	57.62	60.19	62.37	64.65	67.22	70.26	74.43	77.95	80.21	84.40	86.84	91.58	100
19	0	6.81	12.31	14.83	20.27	23.34	28.54	34.97	40.07	44.48	48.89	53.53	60.22	64.49	72.48	77.96	81.03	85.89	88.29	92.56	100
20	0	4.53	9.80	13.33	20.39	24.10	28.93	34.41	38.53	42.55	46.66	51.04	55.93	61.47	68.59	75.16	78.98	84.78	88.14	93.19	100
21	0	5.17	9.49	11.83	16.49	18.75	22.49	26.94	30.20	32.99	35.54	38.14	40.96	44.44	49.94	55.41	59.78	67.31	71.61	80.71	100
22	0	7.98	14.71	18.06	25.48	29.39	35.08	41.05	44.95	48.09	51.18	54.52	58.36	63.24	70.09	75.51	78.75	84.35	87.16	92.41	100
23	0	4.64	10.31	13.43	18.90	21.74	26.34	32.86	37.85	42.35	46.56	50.97	55.65	60.94	67.98	73.51	76.93	83.32	86.73	92.45	100
24	0	3.25	6.22	8.25	13.47	16.78	22.44	29.49	35.04	39.95	43.84	47.38	50.95	56.22	63.99	69.67	72.99	78.56	81.99	90.44	100
25	0	5.80	12.37	16.03	23.67	28.37	35.19	42.54	47.38	51.17	54.47	57.19	59.93	63.48	69.09	73.84	76.79	82.71	85.78	92.29	100
26	0	5.84	12.41	15.58	22.51	26.24	31.98	38.21	42.48	46.35	49.78	53.03	56.91	61.37	67.52	73.44	77.59	84.51	87.86	93.66	100
27	0	5.93	10.34	12.89	17.62	20.31	24.82	30.66	35.24	39.21	42.98	46.89	51.32	57.01	64.68	71.35	75.15	81.59	84.37	89.63	100
28	0	7.13	15.19	18.61	24.34	27.31	32.05	38.38	43.31	47.77	52.12	56.58	61.33	66.70	73.33	78.40	81.43	86.50	89.10	93.41	100
29	0	7.47	15.46	19.86	26.71	29.90	34.48	39.83	43.51	47.00	50.58	54.41	58.77	64.11	71.19	76.33	79.40	85.01	87.76	92.88	100
30	0	8.32	17.50	22.55	30.91	34.69	41.07	48.34	53.22	57.02	60.18	63.06	66.00	69.48	73.90	77.46	79.84	82.97	85.47	89.45	100

Table 66, Discriminant Function Values: November

Function value = (a x lat) + (b x elev) + (c x P/E) + (d x K) + (e x mrange) + (f x drange) + (g x nmax) + (h x nmin) + constant

Group	a	b	c	d	e	f	g	h	constant
1	12.887	0.017	-0.870	0.709	6.826	-23.116	25.933	-16.917	-914.83
2	12.160	0.000	0.216	-0.264	5.290	-17.964	21.959	-13.900	-852.26
3	10.151	-0.002	-0.581	0.778	5.642	-20.109	24.207	-15.868	-681.41
4	10.226	-0.003	-0.708	-0.057	5.961	-21.923	25.452	-16.364	-709.21
5	13.082	-0.003	-0.492	-0.571	5.339	-20.325	23.705	-14.790	-769.45
6	11.356	0.002	-0.623	1.348	6.856	-24.592	25.300	-17.083	-782.21
7	11.383	-0.003	-0.862	-1.351	6.423	-22.322	24.808	-17.810	-646.19
8	17.425	-0.003	-1.116	0.954	6.097	-24.208	27.160	-17.414	-1094.70
9	11.035	0.006	-0.630	1.818	5.753	-19.911	23.386	-15.773	-719.51
10	5.704	0.001	-0.285	-1.196	8.932	-36.724	33.276	-26.497	-771.88
11	20.559	-0.007	-1.384	0.597	5.498	-24.016	27.240	-17.381	-1252.05
12	10.575	-0.001	-0.509	1.002	5.417	-18.456	23.403	-15.567	-685.76
13	11.896	0.021	-0.769	1.083	5.505	-18.036	23.687	-15.312	-821.97
14	15.058	-0.003	-1.040	-0.584	5.906	-22.176	25.748	-15.885	-907.33
15	9.423	-0.003	-0.866	-1.108	7.414	-30.964	30.717	-22.336	-749.68
16	11.085	0.000	-0.482	1.460	5.667	-21.219	23.236	-16.085	-658.94
17	13.060	0.000	-0.773	0.033	5.653	-21.297	25.014	-16.315	-771.42
18	13.822	0.011	-0.944	0.383	6.897	-24.716	26.759	-17.164	-945.59
19	11.486	0.008	-0.816	1.241	5.387	-19.377	24.973	-16.723	-765.57
20	11.760	-0.001	-0.303	1.187	4.980	-20.448	22.870	-15.450	-672.18
21	11.047	-0.003	-0.870	-1.208	6.213	-23.436	24.325	-17.561	-586.24
22	11.636	0.004	-0.681	1.944	6.046	-21.386	24.300	-16.133	-783.86
23	11.033	-0.002	-0.552	1.211	5.539	-20.489	23.688	-16.276	-664.02
24	16.479	-0.004	-0.848	-0.764	4.872	-19.954	22.592	-14.382	-835.48
25	12.938	0.006	-0.836	1.690	6.994	-24.638	26.333	-17.747	-910.18
26	12.227	-0.001	-0.577	1.817	5.573	-22.210	23.909	-15.962	-738.16
27	12.037	-0.002	-0.875	0.701	5.650	-21.224	25.692	-17.847	-736.89
28	10.615	0.003	-0.552	1.217	5.609	-19.749	23.593	-15.617	-689.93
29	11.070	0.002	-0.558	1.585	6.004	-21.730	23.903	-16.022	-717.71
30	9.834	-0.003	-0.764	-0.371	5.510	-22.901	24.614	-15.535	-629.72

INPUT VARIABLES
lat = latitude
elev = elevation
P/E = Precipitation Effectiveness Index
K = Continentality
mrange = monthly temperature range
drange = daily temperature range
nmax = normalized mean daily maximum temperature
nmin = normalized mean daily minimum temperature

Table 67. Temperature Frequency Equations: November

Group	If Input Normalized Temperature (T) < 50th Percentile Normalized Temperature (T)	Maximum Error E1	Maximum Error E2	50th Percentile Normalized T	Group	If Input Normalized Temperature (T) > 50th Percentile Normalized Temperature (T)	Maximum Error E3	Maximum Error E4
1	F=-0.0047+0.0034155*T-0.000259526*T^2+6.10895e-006*T^3	0.008	0.009	57.50	1	F=-6.1763+0.218839*T-0.00221804*T^2+7.47072e-006*T^3	0.006	0.002
2	F=-0.0040+0.00348039*T-0.000247507*T^2+5.05686e-006*T^3	0.009	0.009	62.79	2	F=-11.6387+0.393995*T-0.00407915*T^2+1.40276e-005*T^3	0.009	0.009
3	F=0.0045-0.00218757*T+0.000115062*T^2+1.34959e-006*T^3	0.005	0.005	57.10	3	F=-1.5469+0.0400902*T+1.65063e-005*T^2-1.63385e-006*T^3	0.009	0.011
4	F=-0.0022+0.00140067*T-0.000107188*T^2+3.42222e-006*T^3	0.003	0.003	62.32	4	F=-4.3608+0.128928*T-0.000925662*T^2+1.72087e-006*T^3	0.004	0.008
5	F=-0.0051+0.00323601*T-0.000228405*T^2+5.21707e-006*T^3	0.007	0.008	59.97	5	F=-12.9174+0.464373*T-0.00515485*T^2+1.90308e-005*T^3	0.007	0.006
6	F=-0.0027+0.00649274*T-0.000527572*T^2+1.07429e-005*T^3	0.007	0.009	54.03	6	F=-5.3189+0.200862*T-0.00212952*T^2+7.52881e-006*T^3	0.005	0.001
7	F=0.0020-0.00101713*T-5.82632e-007*T^2+9.64961e-006*T^3	0.003	0.004	38.31	7	F=-4.6776+0.270897*T-0.00486468*T^2+3.88786e-005*T^3-1.16437e-007*T^4	0.004	0.001
8	F=0.0025-0.00131117*T+0.000153993*T^2+7.44477e-007*T^3	0.002	0.003	54.11	8	F=-1.7029+0.0548083*T-0.000243138*T^2-3.5308e-007*T^3	0.007	0.006
9	F=0.0031-0.000468987*T-5.80039e-005*T^2+6.46744e-006*T^3	0.005	0.011	46.65	9	F=-2.4627+0.104779*T-0.00104792*T^2+3.46237e-006*T^3	0.003	0.003
10	F=0.0004+0.00293518*T-0.000316234*T^2+8.4805e-006*T^3	0.003	0.008	52.40	10	F=-2.9200+0.106627*T-0.000918911*T^2+2.44255e-006*T^3	0.008	0.012
11	F=0.0072-0.00442155*T+0.000337469*T^2+4.73344e-007*T^3	0.008	0.013	44.05	11	F=-1.9823+0.0900358*T-0.00089991*T^2+2.97497e-006*T^3	0.014	0.003
12	F=0.0046-0.00280922*T+0.000205958*T^2+7.03936e-007*T^3	0.005	0.004	51.59	12	F=-1.5301+0.0533832*T-0.000267942*T^2-1.34654e-007*T^3	0.008	0.009
13	F=0.0020+0.000129121*T-0.000102243*T^2+5.64857e-006*T^3	0.002	0.009	51.50	13	F=-2.8453+0.108863*T-0.00101195*T^2+3.07693e-006*T^3	0.002	0.002
14	F=-0.0006+0.00141026*T-0.000146975*T^2+4.33445e-006*T^3	0.002	0.003	60.41	14	F=12.6817-0.814504*T+0.0184397*T^2-0.00017198*T^3+5.73517e-007*T^4	0.006	0.006
15	F=0.0005+0.00166526*T-0.00023328*T^2+8.01e-006*T^3	0.003	0.009	50.19	15	F=-2.9724+0.115637*T-0.00109718*T^2+3.37777e-006*T^3	0.008	0.007
16	F=0.0046-0.00172986*T+3.53303e-005*T^2+5.96865e-006*T^3	0.006	0.013	44.18	16	F=-2.5368+0.114396*T-0.00123013*T^2+4.39735e-006*T^3	0.004	0.003
17	F=-0.0002+0.00145502*T-0.000178984*T^26.33167e-006*T^3	0.002	0.004	52.63	17	F=-5.5674+0.214575*T-0.00233401*T^2+8.4494e-006*T^3	0.007	0.003
18	F=0.0004-0.00480413*T+0.000520375*T^2-1.7605e-005*T^3+2.0124e-007*T^4	0.004	0.003	62.37	18	F=-13.8378+0.481396*T-0.00519973*T^2+1.86951e-005*T^3	0.004	0.002
19	F=0.0051-0.00271436*T+0.000159299*T^2+2.18567e-006*T^3	0.006	0.008	48.89	19	F=-1.4938+0.059041*T-0.000406838*T^2+6.54567e-007*T^3	0.007	0.005
20	F=-0.0036+0.00512503*T-0.000688122*T^2+3.02467e-005*T^3-2.75607e-007*T^4	0.007	0.007	46.66	20	F=-1.9916+0.0848069*T-0.000786146*T^2+2.36932e-006*T^3	0.008	0.003
21	F=0.0019-0.000253623*T-0.000113543*T^2+1.46281e-005*T^3	0.003	0.006	35.54	21	F=-4.6049+0.285979*T-0.00547242*T^2+4.64031e-005*T^3-1.46719e-007*T^4	0.005	0.001
22	F=-0.0030+0.0031429*T-0.000292567*T^2+8.28744e-006*T^3	0.005	0.006	51.18	22	F=-3.7681+0.147504*T-0.00152007*T^2+5.21795e-006*T^3	0.001	0.006
23	F=0.0060-0.00324215*T+0.000220556*T^2+1.71988e-006*T^3	0.007	0.007	46.56	23	F=-2.1161+0.0897097*T-0.000843416*T^2+2.57507e-006*T^3	0.008	0.005
24	F=0.0019-0.00122043*T+0.000225698*T^2+1.3977e-006*T^3	0.002	0.003	43.84	24	F=-2.5613+0.117165*T-0.00128538*T^2+4.69937e-006*T^3	0.006	0.001
25	F=-0.0032+0.00222548*T-0.000174607*T^2+5.56217e-006*T^3	0.003	0.003	54.47	25	F=-7.3049+0.277927*T-0.00309858*T^2+1.15004e-005*T^3	0.006	0.005
26	F=0.0004+0.00075324*T-0.000114275*T^2+6.08506e-006*T^3	0.002	0.007	49.78	26	F=-3.9936+0.161278*T-0.00173921*T^2+6.25841e-006*T^3	0.006	0.002
27	F=0.0047-0.00293494*T+0.000205074*T^2+3.14219e-006*T^3	0.005	0.006	42.98	27	F=-1.9810+0.0931686*T-0.000970022*T^2+3.36406e-006*T^3	0.001	0.001
28	F=0.0058-0.00248205*T+8.51788e-005*T^2+2.84428e-006*T^3	0.009	0.010	52.12	28	F=-2.0929+0.0756223*T-0.000554335*T^2+1.06887e-006*T^3	0.006	0.006
29	F=0.0011+0.00129244*T-0.000204938*T^2+7.50119e-006*T^3	0.005	0.012	50.58	29	F=-2.7745+0.10796*T-0.00101253*T^2+3.10108e-006*T^3	0.002	0.004
30	F=-0.0035+0.00277491*T-0.00021592*T^2+5.11436e-006*T^3	0.006	0.003	60.18	30	F=-9.1060+0.315391*T-0.00326733*T^2+1.12379e-005*T^3	0.009	0.007

E1 = Maximum Prediction Error When Computed Frequency < 5%

E2 = Maximum Prediction Error When Computed Frequency Between 5 - 50%

E3 = Maximum Prediction Error When Computed Frequency Between 50 - 95%

E4 = Maximum Prediction Error When Computed Frequency >95%

Table 68. Percent Probability of Predicted Temperatures >2.0C at Each Frequency Level by Group

Month: November

GROUP	STANDARDIZED FREQUENCY LEVELS 0.001	0.005	0.01	0.03	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	0.95	0.97	0.99	0.995	0.999	% OF ALL > 2.0C
1	28	42	56	28	28	14	28	28	14	14	0	0	0	0	0	0	0	0	0	15.0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
3	5	5	5	5	5	5	5	5	5	5	5	10	10	10	10	5	5	5	5	6.1
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	17	0	0	0	0	0	0.9
8	0	0	17	17	17	17	17	17	17	17	17	17	17	17	0	0	0	0	0	10.5
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
11	0	33	33	33	33	33	33	33	0	0	0	0	0	33	33	33	33	0	0	19.3
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
13	6	18	18	18	18	18	18	18	12	6	12	12	6	6	0	0	0	0	0	10.2
14	0	25	25	25	25	25	0	0	0	0	0	0	0	0	0	0	0	0	0	6.6
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
18	25	25	25	25	25	25	25	25	25	25	25	25	25	0	0	0	0	0	0	17.1
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
20	0	0	14	0	0	0	0	0	0	0	14	14	0	0	0	14	14	14	14	5.3
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
24	0	0	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	0	28.0
25	20	20	0	20	20	20	20	20	20	0	20	20	20	20	20	20	20	20	20	17.9
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
29	0	0	0	7	0	0	0	0	0	0	0	0	0	7	7	0	0	0	0	1.0
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0

normalized temperatures in Table 65, discriminant functions in Table 66, curve-fitting equations in Table 67, and percent probabilities by frequency level in Table 68.

Residuals

In the course of this analysis, 62,928 residuals were generated. This figure represents 19 levels generated for each of the 276 stations for all 12 months. These residuals represent the differences between the group mean curves and each of the station curves. Monthly error means and standard deviations for both the model and validation data set residuals are shown in Figure 76. As discussed in Dillon and Goldstein (1984), two assumptions concerning residuals (errors) from linear models are that their expected

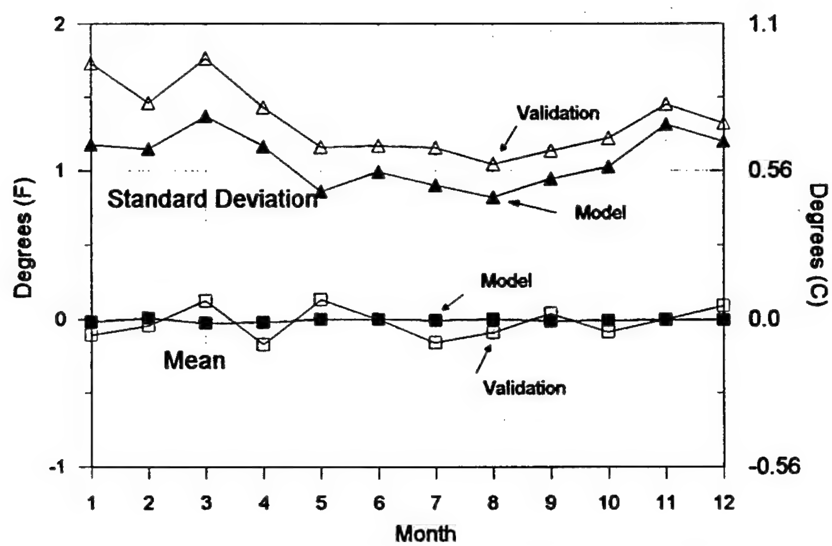

Figure 76. Monthly Error Means and Standard Deviations For Model Building and Validation Data Sets

or mean value should be 0.0 and their variance should be a constant. As expected, these measures for the monthly model building data sets are closer to 0.0 for the mean and 1.0 for the standard deviation than are those for the validation data set. Standard deviations also are smaller during the summer months and increase during the winter months. This is in keeping with the model's performance -- better predictive capability during the summer and poorer during the winter.

Figures 77 to 88 contain monthly histograms showing the distribution of the combined model building and validation data base residuals. All but 2 months (May and July) maintain a negative skewness of the residuals with the greatest negative skewness

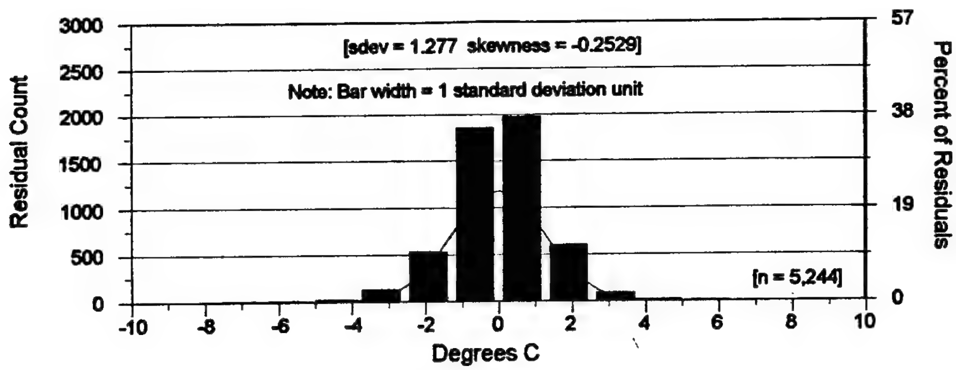

Figure 77. Distribution of Residuals: December

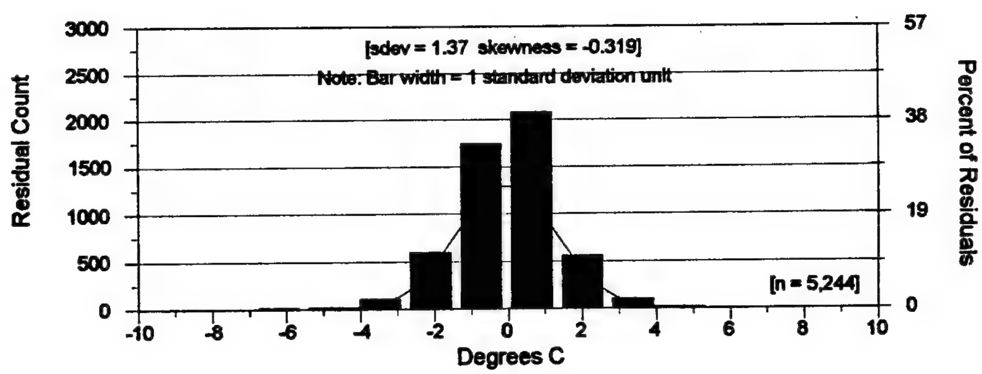

Figure 78. Distribution of Residuals: January

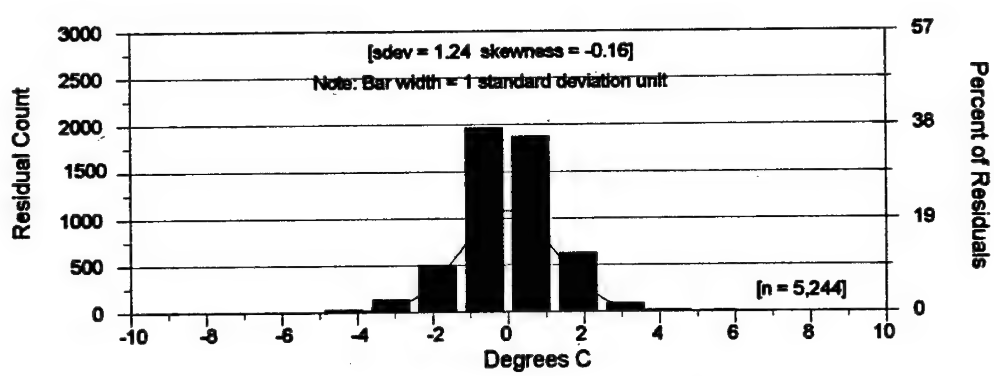

Figure 79. Distribution of Residuals: February

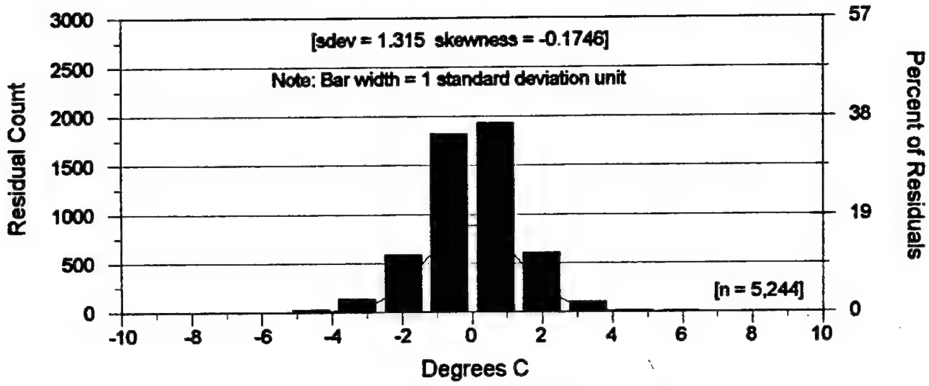

Figure 80. Distribution of Residuals: March

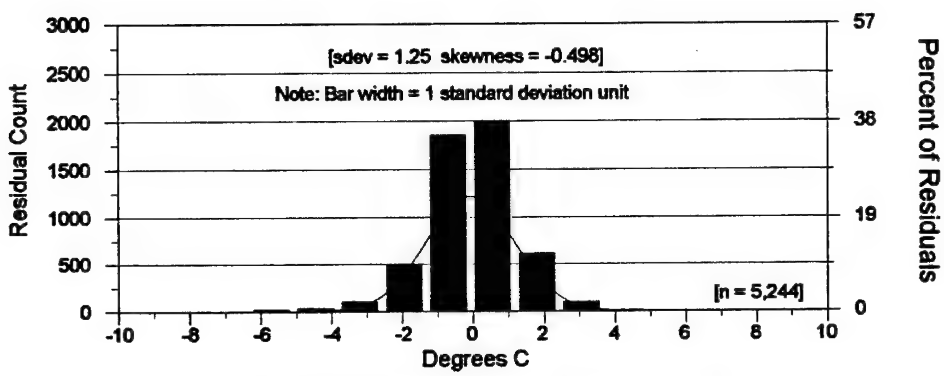

Figure 81. Distribution of Residuals: April

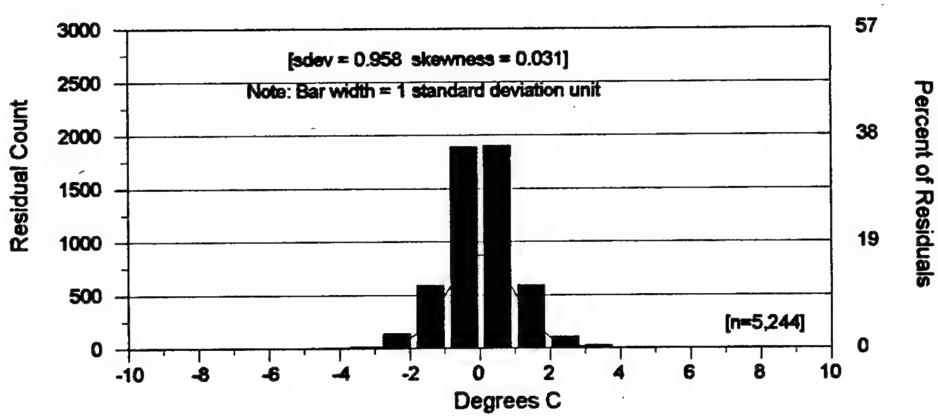

Figure 82. Distribution of Residuals: May

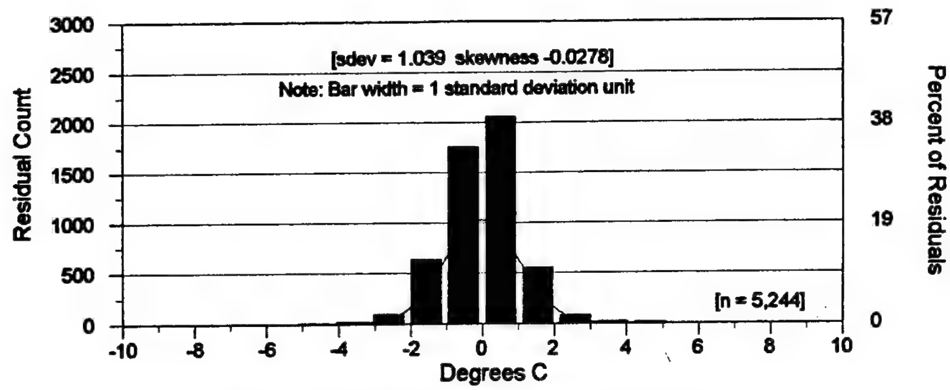

Figure 83. Distribution of Residuals: June

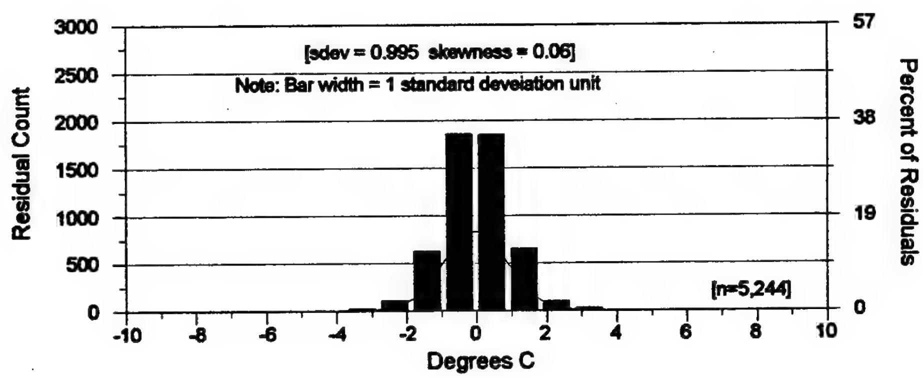

Figure 84. Distribution of Residuals: July

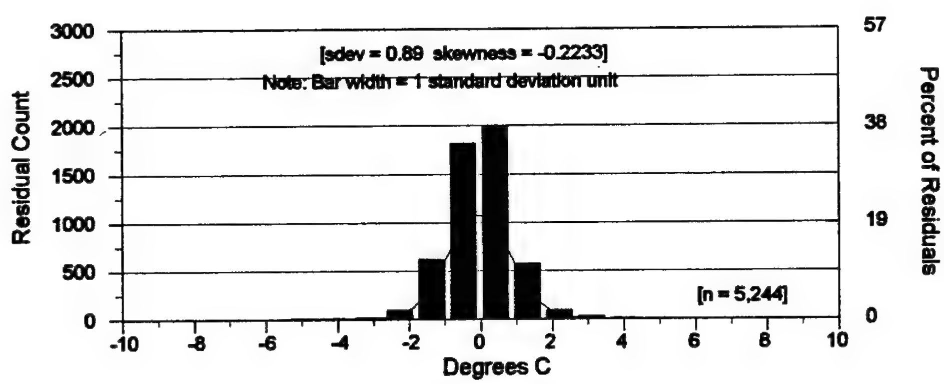

Figure 85. Distribution of Residuals: August

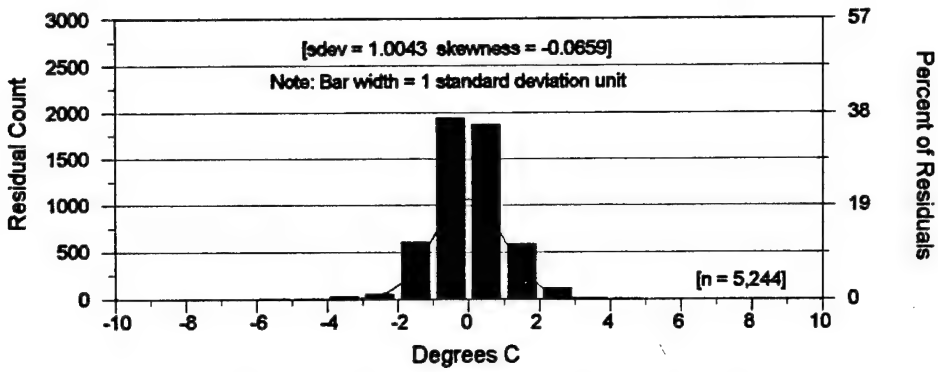

Figure 86. Distribution of Residuals: September

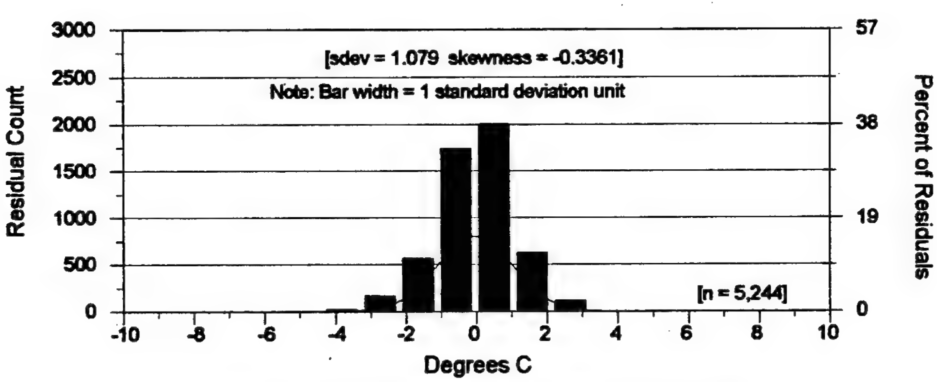

Figure 87. Distribution of Residuals: October

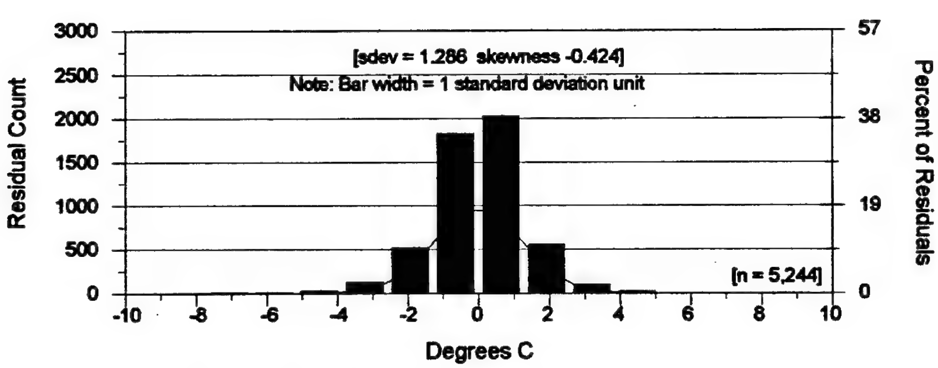

Figure 88. Distribution of Residuals: November

occurring during the colder months. This is in line with model performance -- the greatest magnitude of the errors occurring at the colder temperatures and during the colder times of the year.

For the purposes of this analysis, an error has been defined as the difference between the actual temperature and the predicted temperature at any of the 19 points along the cumulative frequency distribution being in excess of 2.0°C. Annually, 4,669 out of 62,928 estimated temperatures (7.5 percent) differed from the actual temperatures by >2.0°C (92.5 percent of all residuals were within tolerance). Table 69 presents the monthly breakdowns of number of stations versus the number of levels outside of the error tolerance for the combined data set (276 stations). August is the best month, with 243 of its stations out of 276 (approximately 88 percent) having no error. March is worst, with only 153 stations out of 276 (about 55 percent) having no error. Annually, a little over 72 percent of all the stations had all of the levels within tolerance. It also can be seen that during the colder months several stations had practically all of their levels out of tolerance.

Figure 89 shows the percent of all predicted levels for each month within the +/-2.0°C tolerance range for the model building, validation and combined data sets. Predictive capability is best during the summer months and poorest during the winter and early spring. These results mirror the findings of Spreen (1956), Lackey (1960b) and

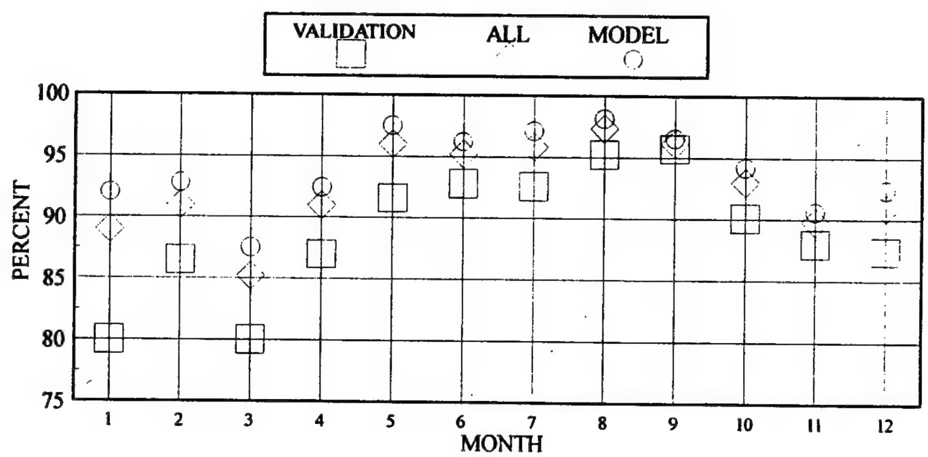

Figure 89. Percent of Predicted Levels within +/- 2C for Model Building, Validation, and Combined Data Sets by Month

Tattleman and Kantor (1977). Their models had an inordinate amount of trouble handling low temperature stations especially during the winter months. The accuracy of the model when applied to the validation data sets also shows poorer performance during January to March,and the best performance during summer through fall. The heightened temperature

Table 69. Number of Stations vs. Number of Frequency Levels Out of Tolerance for Combined Model Building and Validation Data Sets

	Number of Levels with Absolute Error > 2.0 C																			
Month	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
January	164	14	9	13	16	12	8	8	7	4	3	3	4	3	1	3	2	1	1	0
February	175	15	11	11	11	12	11	6	8	5	1	3	6	0	0	1	0	0	0	0
March	153	11	10	13	11	8	10	14	7	7	4	6	5	2	4	3	5	1	1	1
April	176	22	10	12	9	9	6	3	8	2	6	1	1	1	1	2	6	1	0	0
May	227	6	9	8	2	5	4	3	6	1	1	2	1	0	1	0	0	0	0	0
June	220	13	10	6	3	4	3	4	1	2	1	2	3	3	0	0	1	0	0	0
July	233	6	3	4	9	3	3	2	4	3	2	0	2	0	1	1	0	0	0	0
August	243	7	4	5	4	4	0	2	3	1	1	0	1	0	1	0	0	0	0	0
September	236	5	7	4	3	4	2	3	5	1	1	2	0	1	1	1	0	0	0	0
October	206	2	7	9	4	8	5	5	5	2	3	1	0	2	4	2	0	1	0	0
November	187	9	10	7	10	12	6	4	4	2	3	3	4	6	3	3	1	1	1	0
December	173	14	10	19	12	9	11	4	4	5	6	3	2	3	1	0	0	0	0	0
Annual Avg.	199.4	10.3	8.3	9.3	7.8	7.5	5.8	4.8	5.2	2.9	2.7	2.2	2.4	1.8	1.5	1.3	1.3	0.4	0.3	0.1
Annual %	0.723	0.037	0.030	0.034	0.028	0.027	0.021	0.018	0.019	0.011	0.010	0.008	0.009	0.006	0.005	0.005	0.005	0.002	0.001	0.000

diversity during the colder periods would account for the fact that there are temperature frequency regimes other than those created by the model. Individual monthly graphs (Figures 90 to 101) show the cumulative percent of predicted levels versus 0.5°C increments. An examination of these graphs shows the flow of the curves to be fairly consistent from month to month, with perhaps the biggest difference (outside of monthly model performance) being the heightened difference between the curves for the model building and validation data sets during the colder months.

Figure 102 shows a comparison of the number of monthly discriminant function groups with the number of stations in the combined data sets that had no errors at any of their frequency levels. Ideally, a parsimonious solution would be to use the fewest number of discriminant function groups and produce the highest number of stations with no errors (i.e., we would like to see a cluster of points in the upper left-hand corner of this chart). As is shown, the summer through early autumn period exhibits this tendency, with August having about 88 percent of all stations with no levels outside the 2.0°C tolerance. Conversely, the period December through March requires a significantly greater number of groups, but produced the fewest number of stations with no errors. Similarly, when the monthly standard deviation of the residuals is compared to the number of stations with no errors (Figure 103), we again find that the warmer months (May through October) possess the smaller standard deviation of the residuals and greater number of stations with no errors, whereas the colder periods (November through March) exhibit the opposite trend.

The analysis, thus far, has shown that the model's performance in terms of the magnitude of the residuals and the number of stations with all levels within tolerance, declines during the colder portions of the year. It would indicate that there is more temperature diversity during the colder seasons and at colder stations, and the developed model is not accounting for this diversity. As an example of this cold season and cold station diversity, Figure 104 shows hourly temperatures for a two-day period during January at several locations on Fort Greely, AK (U.S. Army Meteorological Team, 1988). The stations themselves, all with varying degrees of exposure, are located within approximately a 20 x 25 mi^2 area and function as materiel test sites for the U.S. Army. The degree of exposure to the local ambient weather conditions and topography can account for much of the diversity shown in this graph. Stations 1 through 5 are all located on relatively exposed terrain, whereas Station 6 is located in a depression and sheltered from most of any modifying influences. Curve 6 is the temperature curve for the Bolio Lake Test Facility. Bolio Lake functions as an ambient "cold-soak" test site. With such thermal diversity in a relatively small area as Fort Greely, it is not surprising that a station could be assigned to a group whose mean curve did not provide the most accurate fit and that there are other locations that could have even different thermal environments, which are not represented by any group that was generated in the analysis.

Figures 105 and 106 show the location of errors along the cumulative frequency curve arranged by season and for the year, respectively. Figures 107 to 118 are the

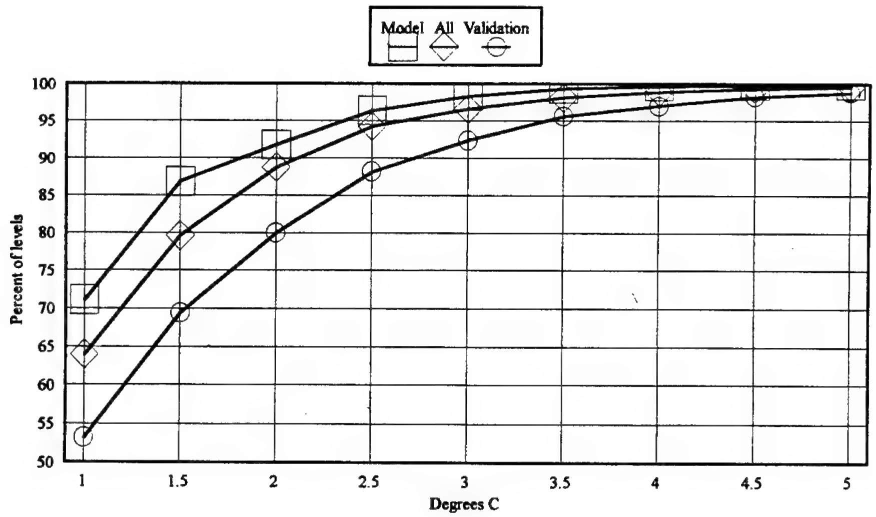

Figure 90. Cumulative Percent of Predicted Levels vs 0.5C Tolerances – January

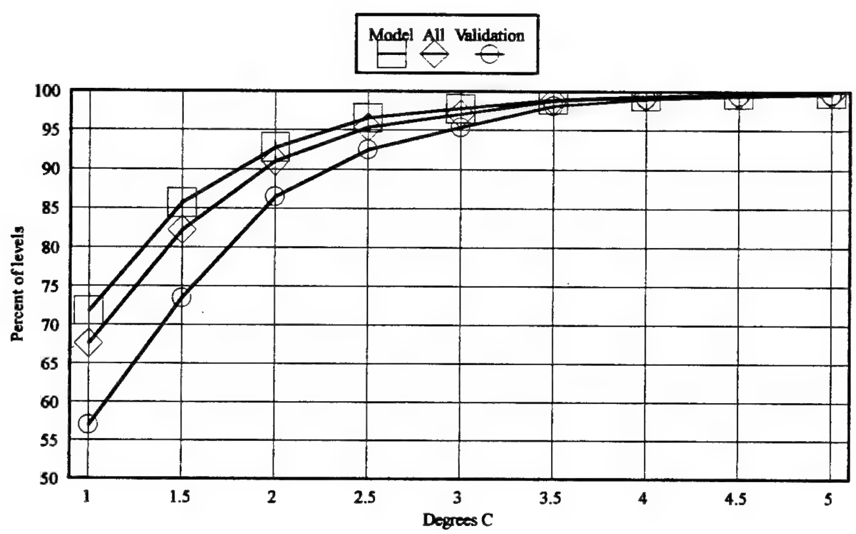

Figure 91. Cumulative Percent of Predicted Levels vs 0.5C Tolerances – February

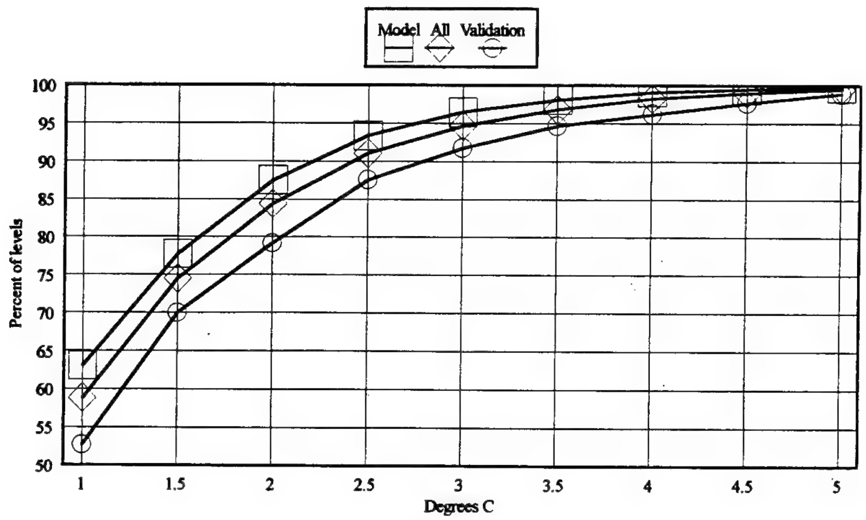

Figure 92. Cumulative Percent of Predicted Levels vs 0.5C Tolerances --March

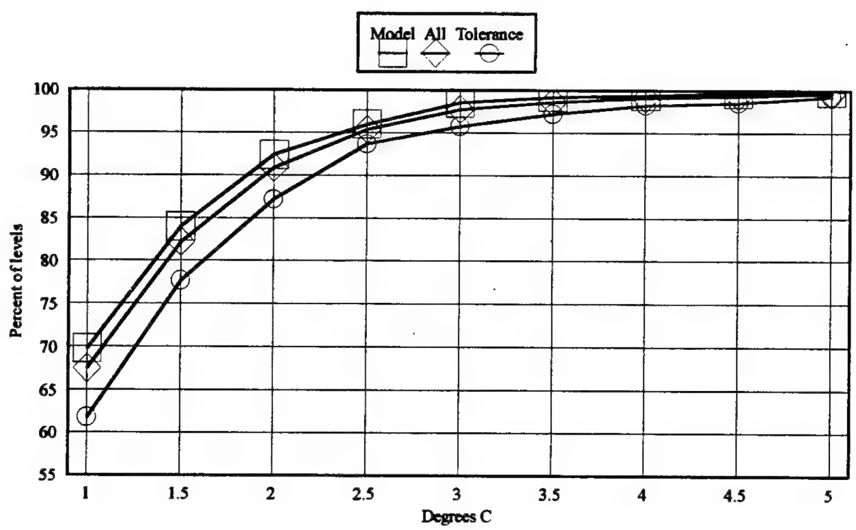

Figure 93. Cumulative Percent of Predicted Levels vs 0.5C Tolerances -- April

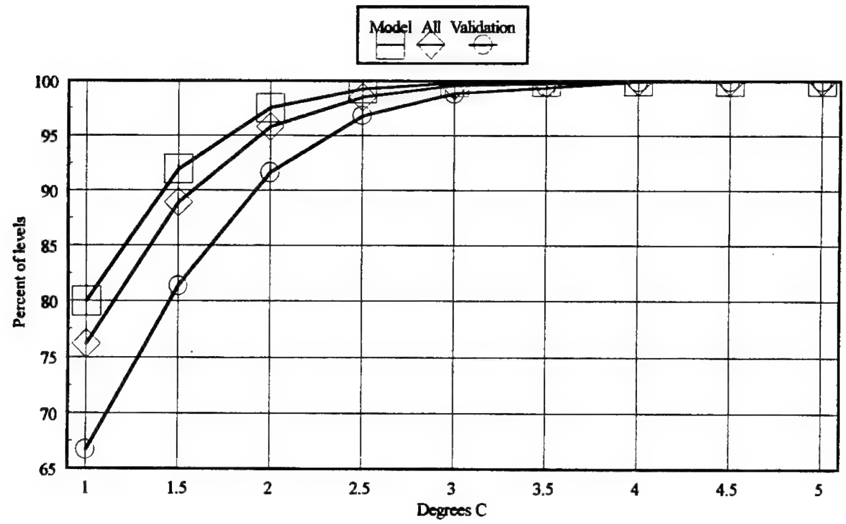

Figure 94. Cumulative Percent of Predicted Levels vs
0.5C Tolerances – May

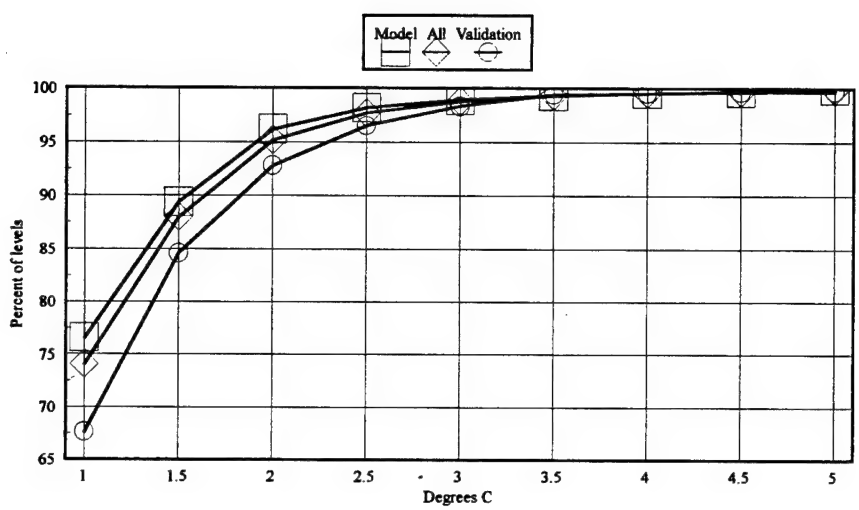

Figure 95. Cumulative Percent of Predicted Levels vs
0.5C Tolerances – June

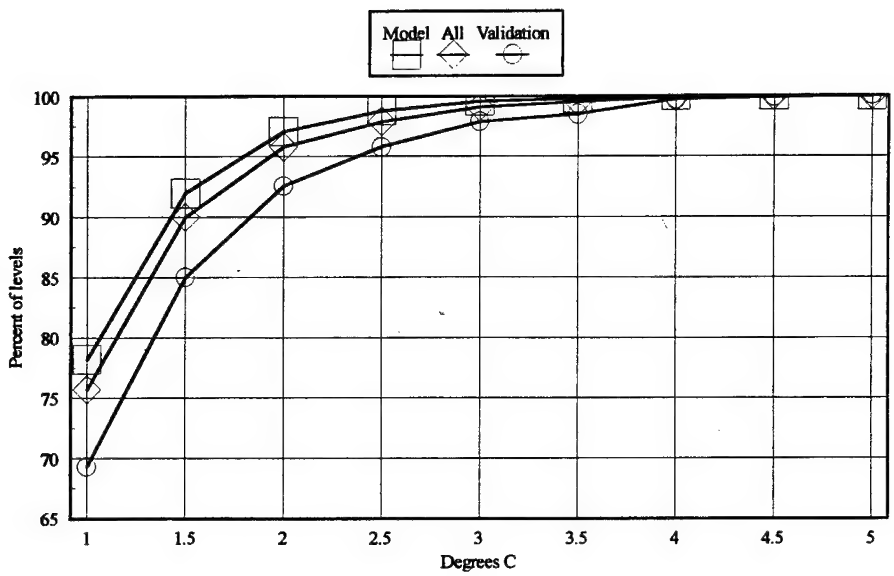

Figure 96. Cumulative Percent of Predicted Levels vs
0.5C Tolerances -- July

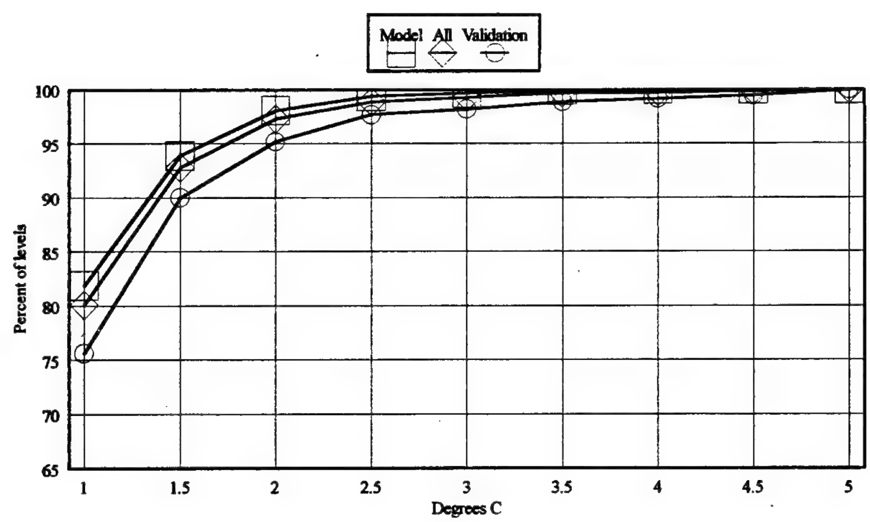

Figure 97. Cumulative Percent of Predicted Levels vs
0.5C Tolerances --August

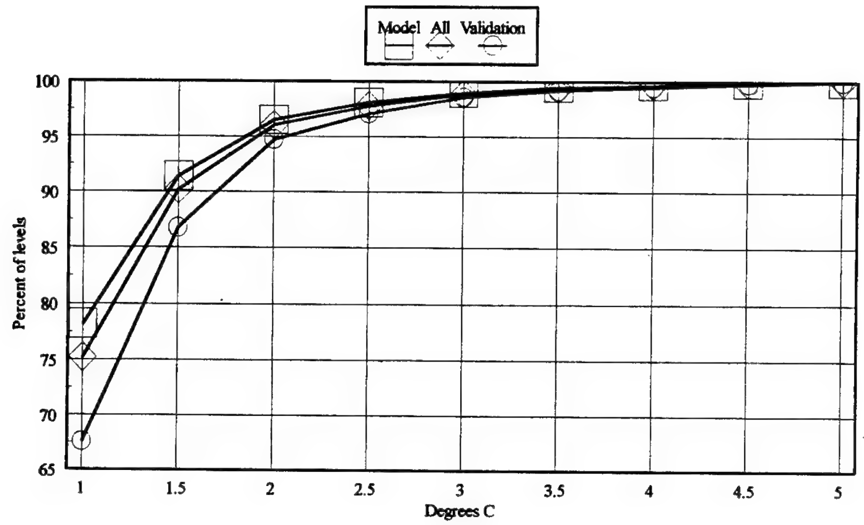

Figure 98. Cumulative Percent of Predicted Levels vs 0.5C Tolerances –September

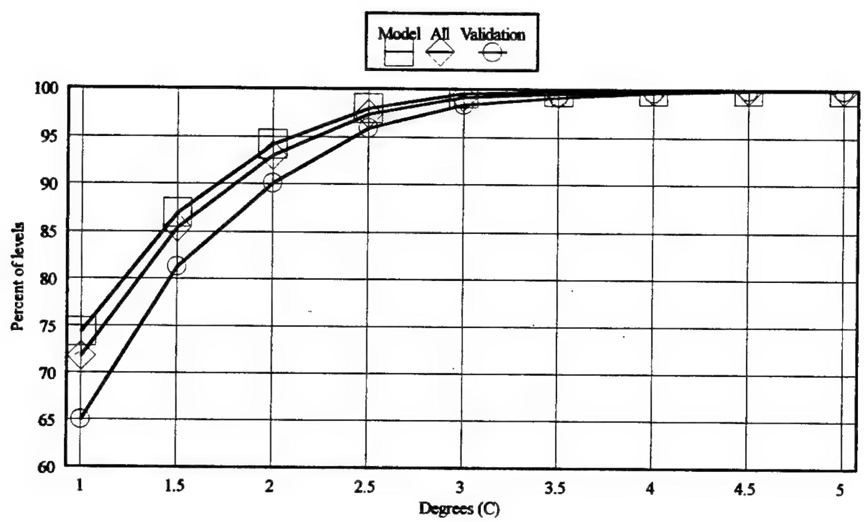

Figure 99. Cumulative Percent of Predicted Levels vs 0.5C Tolerances –October

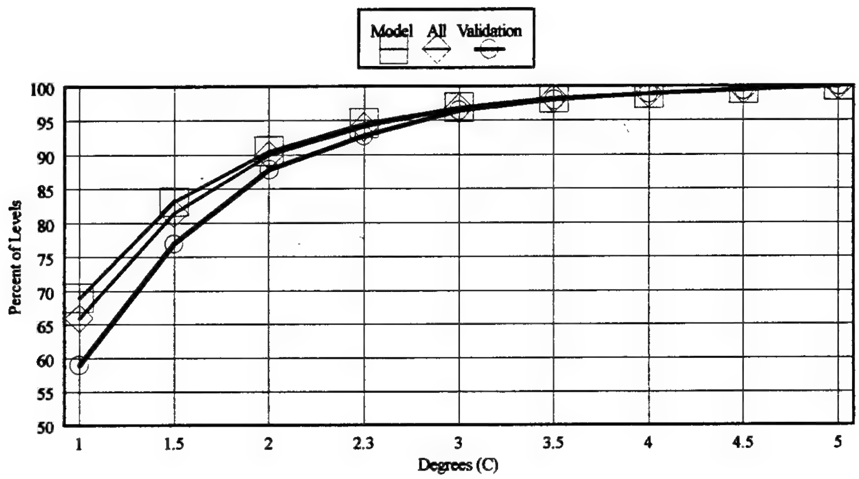

Figure 100. Cumulative Percent of Predicted Levels vs
0.5C Tolerances – November

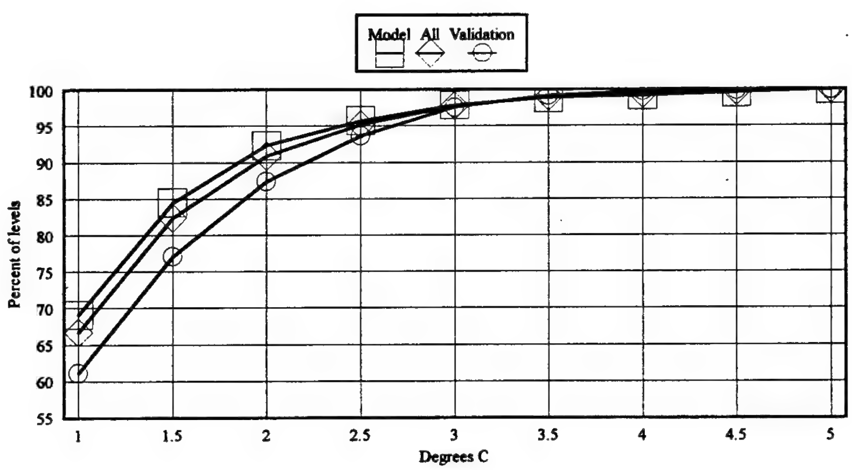

Figure 101. Cumulative Percent of Predicted Levels vs
0.5C Tolerances – December

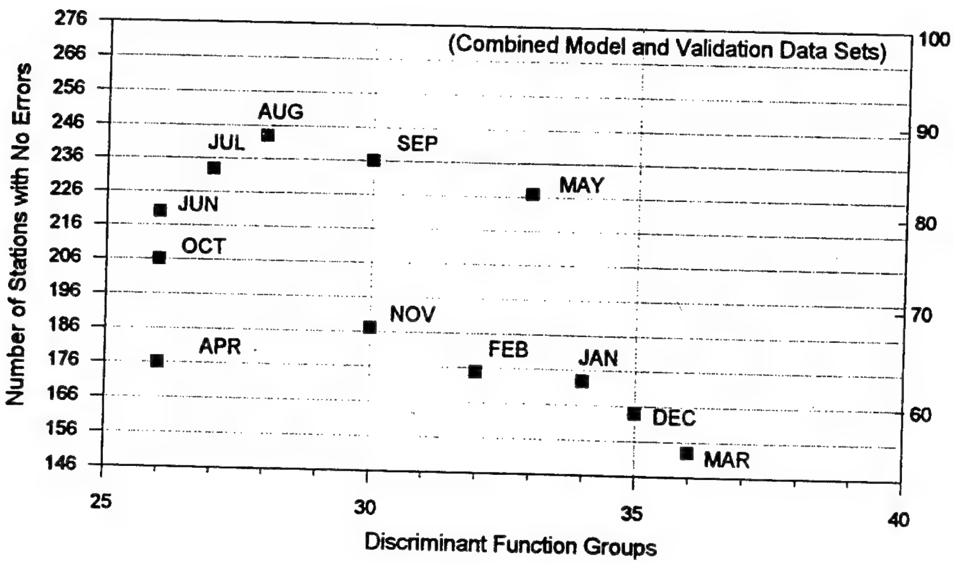

Figure 102. Number of Stations with No Errors vs. Number of Groups

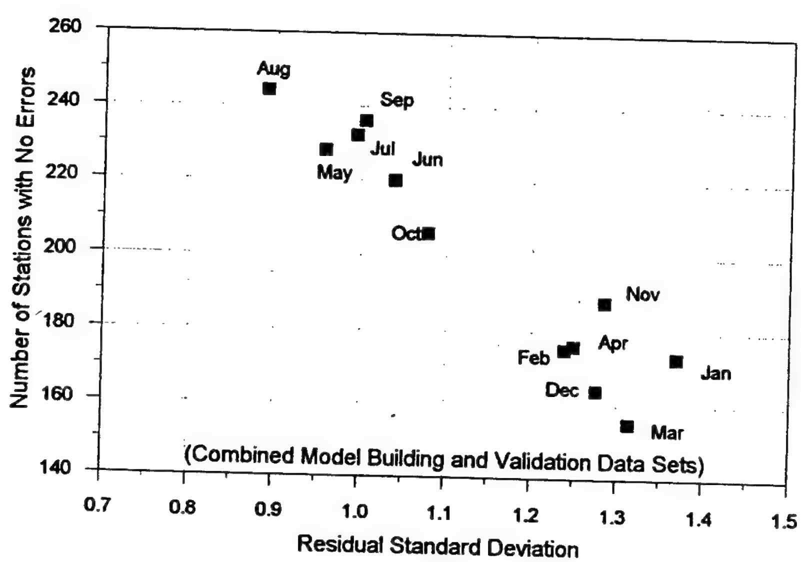

Figure 103. Residual Standard Deviations vs. Number of Stations with No Error

monthly graphs showing error locations along the cumulative frequency curve. It can be readily observed from both the seasonal and the monthly graphs that most errors occurred during the winter months and are located at the lower tail of the distribution. The spring

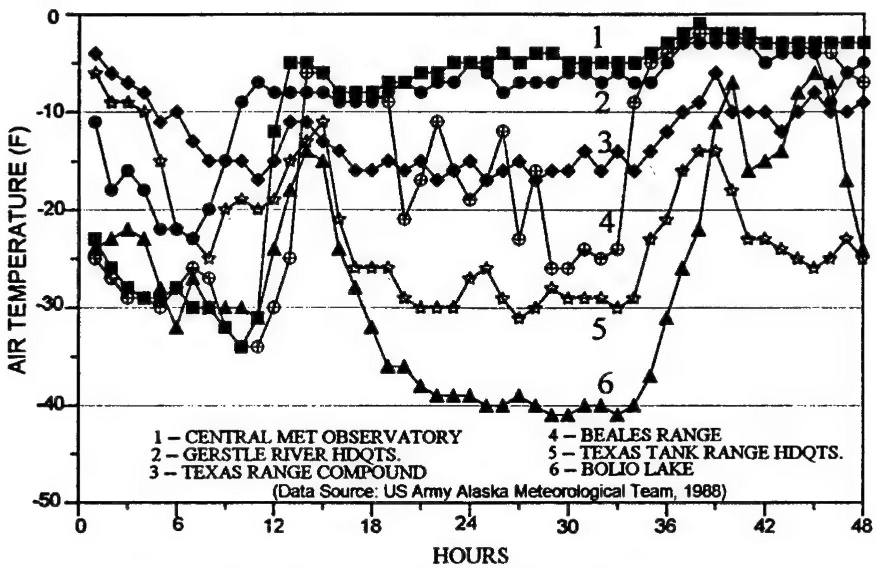

Figure 104. Hourly Air Temperatures (F) for Selected Locations at Fort Greely, Alaska for the Period 27-28 January 1988

pattern follows the winter pattern closely, except that the pattern is not as pronounced in the lower tail of the distribution. Autumn is intermediate to the winter and spring and once again shows the most errors occurring at the lower end of the distribution. Summer, which has the fewest errors, shows the reverse -- most errors occurring at the higher temperatures. It appears that the greater number of errors occurs in the direction of the prevailing extremes. Annually, the lower 10 percent of the curve shows a greater number of errors than the upper 10 percent.

Absolute maximum monthly error for the model building and validation data sets is shown in Figure 119. As expected, the greatest magnitude occurs during late autumn through early spring, and the least during the late spring through the early autumn. Table 70 provides the stations where these maximum errors occurred. From this table it can be seen that the stations exhibiting these maximum errors are located primarily in: cold, high latitude locations; mountainous regions; and the U.S. Pacific Northwest.

Temperature diversity in the high latitudes has already been discussed. Mountainous locations also have extremely diverse thermal environments. Trewartha points out that the profusion of local climates makes it "...impossible for the weather data of most stations to be representative of anything but a very restricted area" (Trewartha,

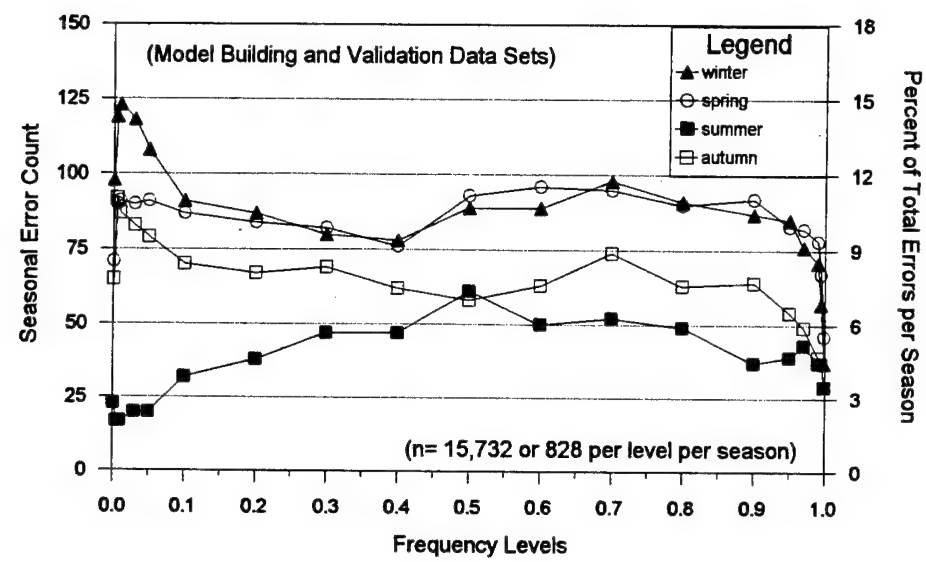

Figure 105. Seasonal Error Counts at Standardized Frequency Levels

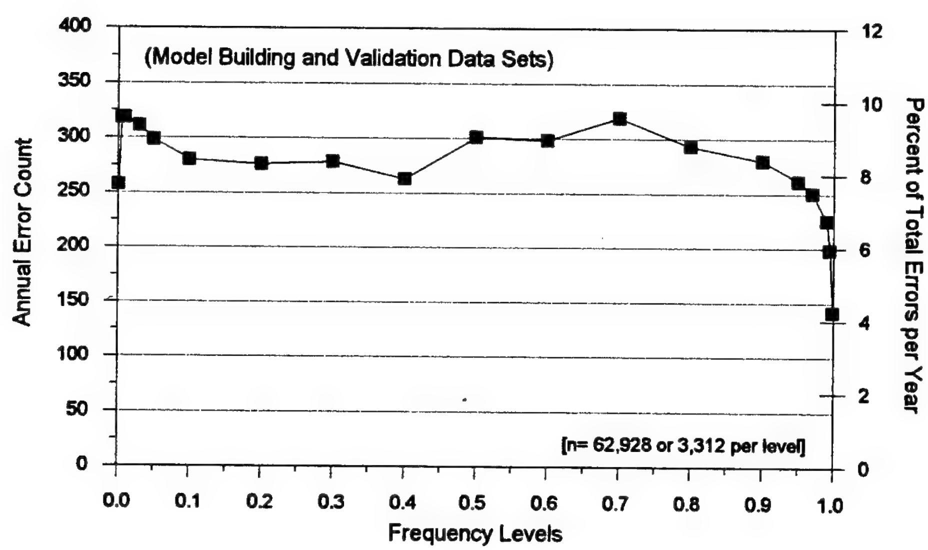

Figure 106. Annual Error Counts at Standardized Frequency Levels

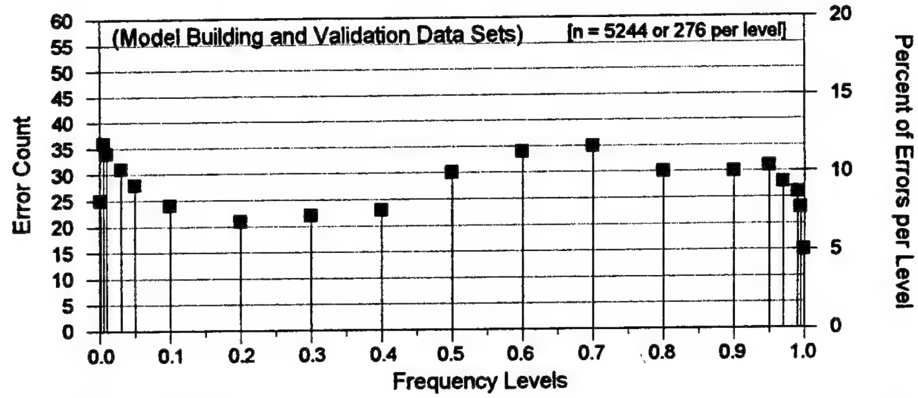

Figure 107. Error Counts at Standardized Frequency Levels for December

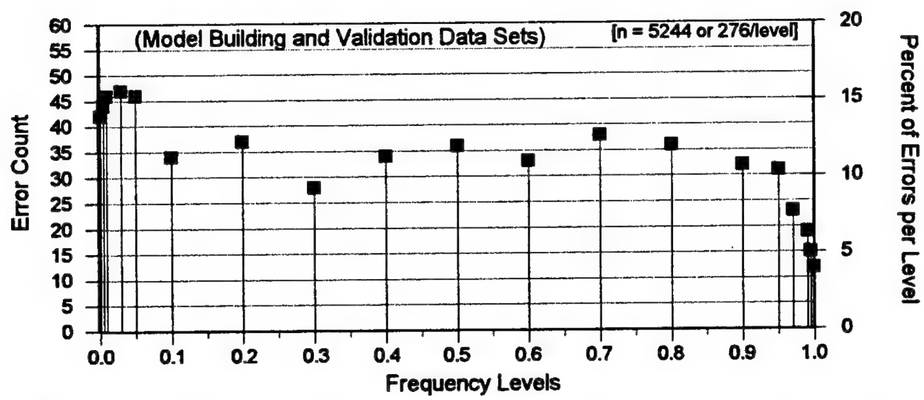

Figure 108. Error Counts at Standardized Frequency Levels for January

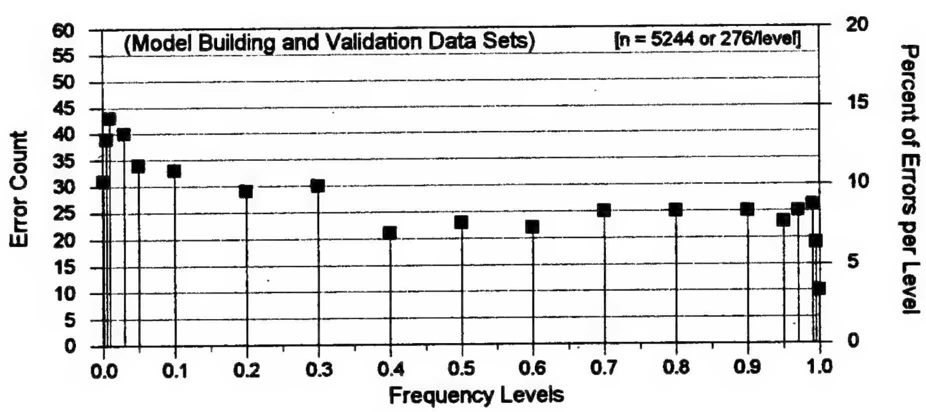

Figure 109. Error Counts at Standardized Frequency Levels for February

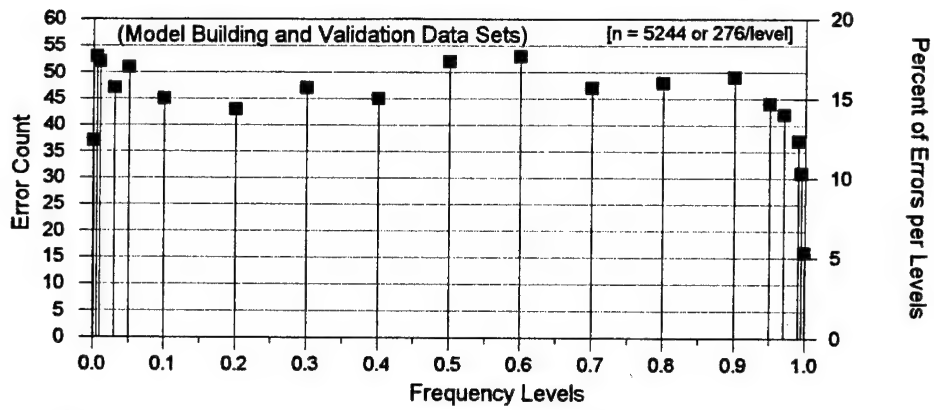

Figure 110. Error Counts at Standardized Frequency Levels for March

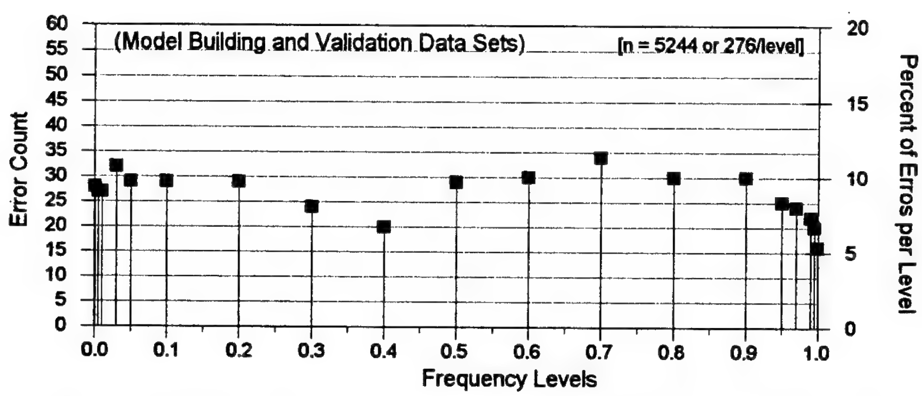

Figure 111. Error Counts at Standardized Frequency Levels for April

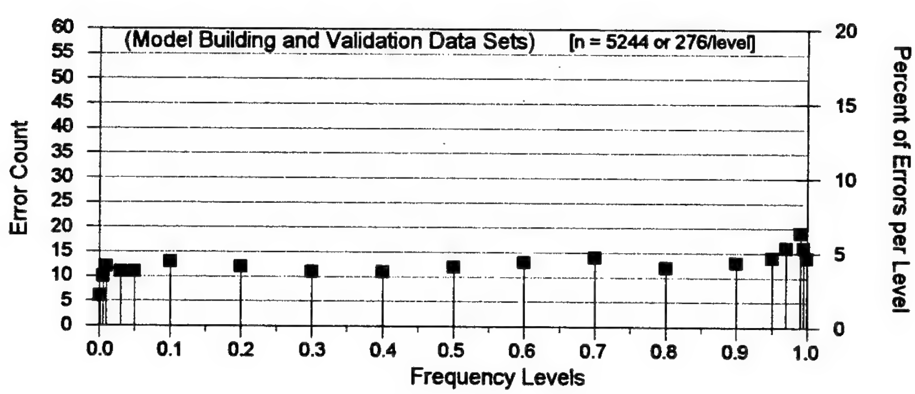

Figure 112. Error Counts at Standardized Frequency Levels for May

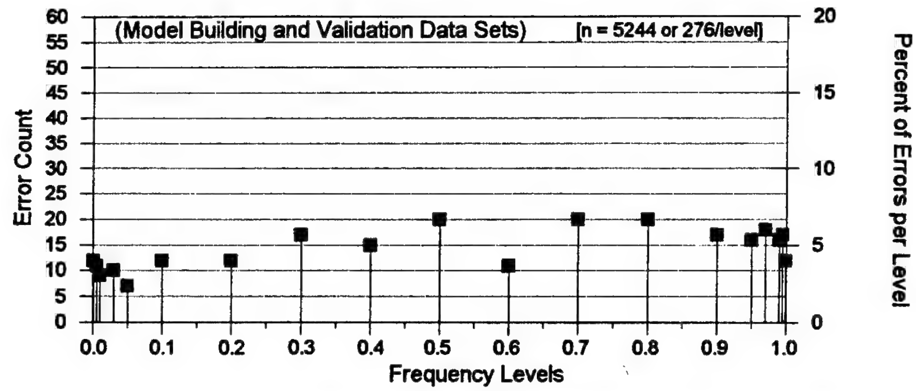

Figure 113. Error Counts at Standardized Frequency Levels for June

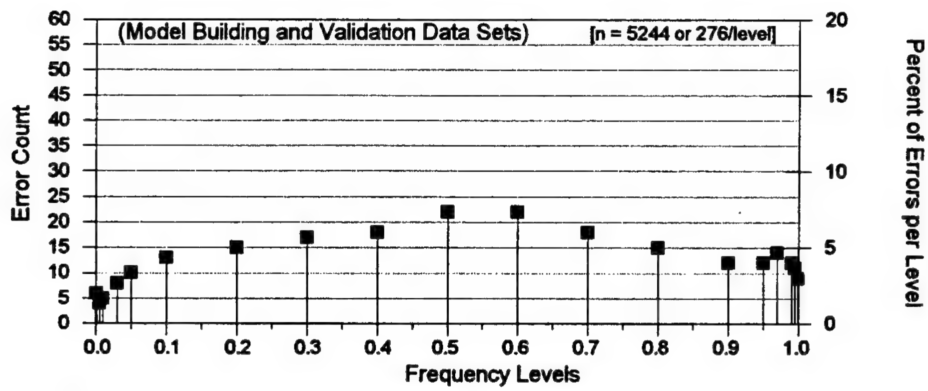

Figure 114. Error Counts at Standardized Frequency Levels for July

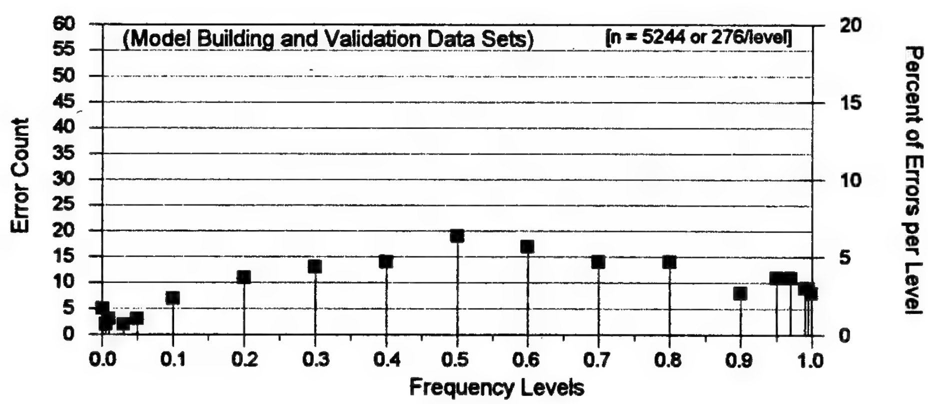

Figure 115. Error Counts at Standardized Frequency Levels for August

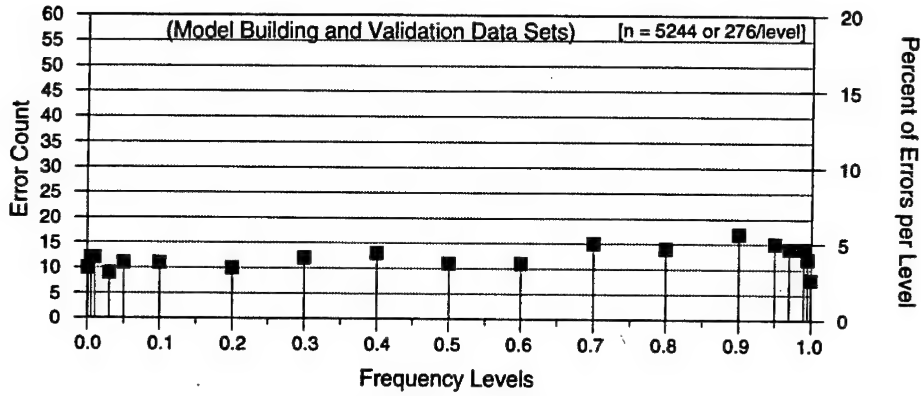

Figure 116. Error Counts at Standardized Frequency Levels for September

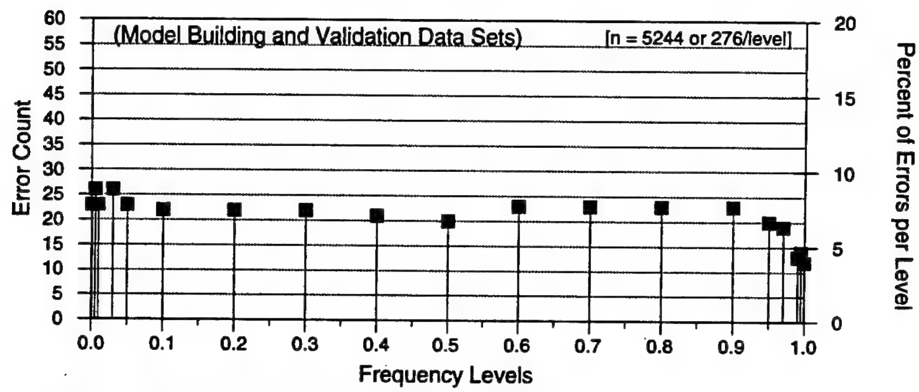

Figure 117. Error Counts at Standardized Frequency Levels for October

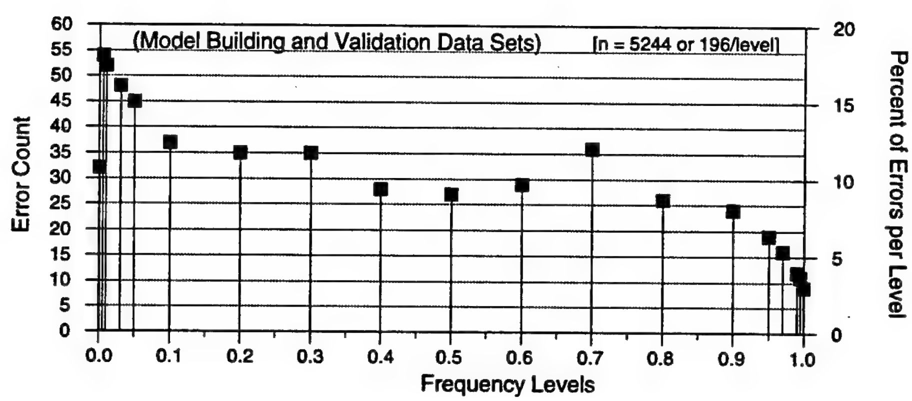

Figure 118. Error Counts at Standardized Frequency Levels for November

1954, p.367). To those factors that control thermal environment in the horizontal direction must be added factors that control it in the vertical -- elevation, slope, aspect,

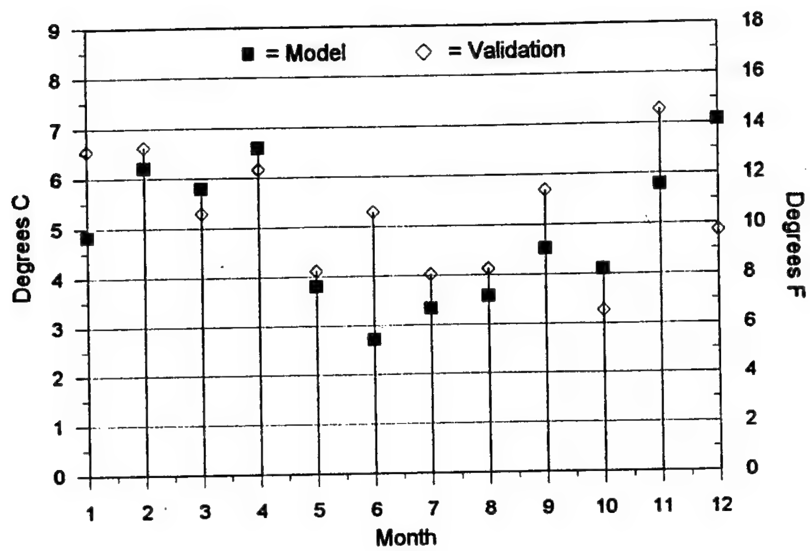

Figure 119. Maximum Absolute Error for Monthly Model Building and Validation Data Sets

Table. 70 Stations with the Greatest Absolute Errors in the Model and Validation Data Sets

Month	Model Building	Validation
January	Sonder Stromford, Greenland	Olympia, Washington
February	King Salmon, Alaska	Seattle-Tacoma, Washington
March	Nord, Greenland	Kodiak, Alaska
April	Calgary, Canada	Anchorage, Alaska
May	Sonder Stromford, Greenland	Kotzebue, Alaska
June	Whidbey Island, Washington	Olympia, Washington
July	Sable Island, Canada	Peoria, Illinois
August	China Lake, California	Nome, Alaska
September	Goose Bay, Canada	Sheridan, Wyoming
October	Denver, Colorado	Seattle-Tacoma, Washington
November	Albuquerque, New Mexico	Nome, Alaska
December	King Salmon, Alaska	Sheridan, Wyoming

and the station's overall situation with relation to the surrounding topography. The climate of an enclosed valley or upland is very different from the climate of an exposed peak (Trewartha, 1968). Barry (1992) also discusses in detail the complexity of the mountainous environments and cites latitude, elevation and topography as being the

factors that exert primary influence. He concurs with Trewartha by stating that "...mountainous terrain sets up such a variety of local weather conditions that any station is likely to be representative of only a limited number of sites" (Barry, 1992, p. 9). The model employed in this research has no way to differentiate between peak and valley stations or stations located along the intermediate slopes. The density of stations within mountainous areas, as previously discussed, is quite sparse and this obviously adds to the poorer model performance within these areas.

The Pacific Northwest of the U.S. also is a place of wide climatic diversity. In the Puget Sound area, for example, the complex terrain produces wide variations in climate over short distances (Lydolph, 1985). Within this area, the windward sides of mountains may receive over 100 inches of rain per year, whereas some leeward locations barely receive 20 inches. From the monthly analysis it was shown that, dependent on the month, up to three to four groups were required to define the temperature frequency patterns in this relatively small geographic area. Trewartha (1968) further notes that the windward sides of mountains have smaller temperature ranges than the leeward sides, with the leeward sides having a tendency toward increased continentality.

Included within each of the monthly discussions are tables that were generated from the combined model building and validation data sets, which show the simple probability of having a predicted temperature >2.0°C at each of the 19 predicted levels for each group. This provides a rough indication of the degree of confidence when a station is assigned to a group, and a temperature is predicted at, or near, a certain frequency level. Of the 363 temperature frequency groups generated for the year, 10 groups had errors in more than 20 percent of all the generated temperature levels for a particular month. Table

Table. 71 Generalized Geographic Locations of Groups Possessing > 20 Percent of Generated Predicted Temperatures Exceeding the 2°C Tolerance

Month	Group	Characteristics
January	1	S. Rocky Mountains-Great Basin
	10	High Arctic
	14	Central Canada
	15	N. U.S. Rocky Mountains
	34	Alaska & N. Canada
February	2	Pacific N.W. & W. Canada Coast
March	2	Pacific N.W. & W. Canada Coast
	23	High Arctic
October	2	Pacific N.W. & W. Canada Coast
November	24	S. Greenland Coast

71 shows these groups and some generalized geographic locational information. Once again, the coldest months exhibited the greatest number of highly erroneous groups, and the general geographic location of these groups are the high arctic, high mountainous areas and the Pacific Coast at latitudes > 45 °N.

Temperature Frequency Curve Shapes

Figures 120 to 131 show the outer boundaries of the normalized temperature frequency group curves for each month. As was previously mentioned, the curves possess the characteristic sigmoid shape. It was decided only to show the outer boundaries of the monthly group curves, inasmuch as displaying the total number of curves generated for a month would make these graphic figures quite unreadable. The boundary groups are defined by group number and the general geographic area they represent. As would be expected, the boundary groups correspond quite closely to the highest positive and lowest negative group mean skewness for each particular month. In several months, two groups formed a boundary, normally criss-crossing near the middle of the distribution.

Table 72 presents the spans of temperature (normalized degrees) at each frequency level for each month. The span represents the distance between the boundary curves at each of the standardized frequency levels. These spans have a fairly good positive correlation ($r^2 = 0.72$) with the skewness ranges for the months. The highest skewness ranges (differences between the highest and lowest group skewness values) are found from March through September, as are the highest monthly average spans. Composite seasonal spans, shown in Figures 132 to 135, show the greatest spans occurring in the colder months at the lower portions of the distribution and occurring in the warmer months at the higher portions of the distributions -- i.e., in the direction of the prevailing extremes.

As a final examination of the curve shape, Figure 136 shows the composite cumulative frequency temperature curves for the seasons. The spring and autumn curves practically overlap and are quite close to normal distributions -- means close to 50 and skewness values of +0.025 and +0.068, respectively. The winter curve bounds on the right and has a skewness of -0.104. The summer curve bounds on the left with a skewness of +0.188. The winter and summer curves are again skewed in the direction of the prevailing extremes. Figure 137 shows the annual composite temperature frequency group curve. This curve is the average of all 363 generated curves for the year. It maintains a slight positive skewness (+0.043), but is fairly close to being a normal distribution. The slight positive skewness also may be the result of station selection -- a higher density of stations in the low to mid-latitudes and a sparser density in the colder high latitudes.

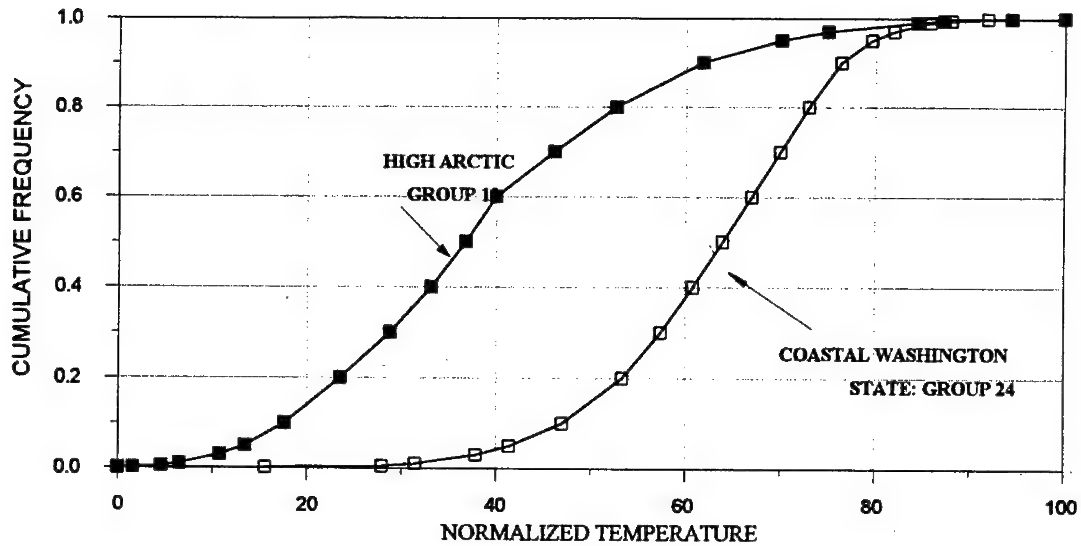

Figure 120. Outer Boundaries for Cumulative Frequency Curves: January

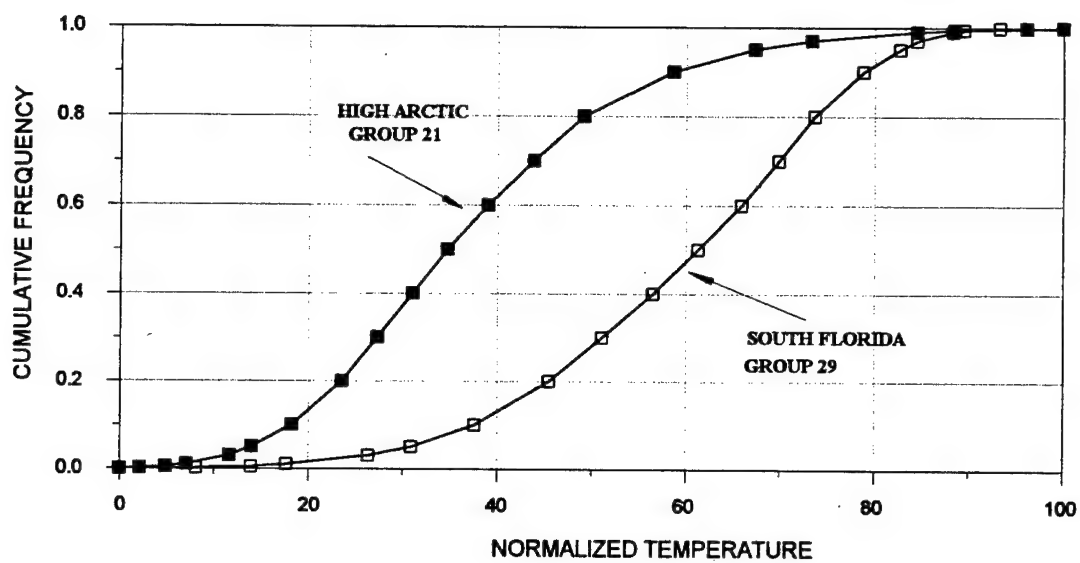

Figure 121. Outer Boundaries for Cumulative Frequency Curves: February

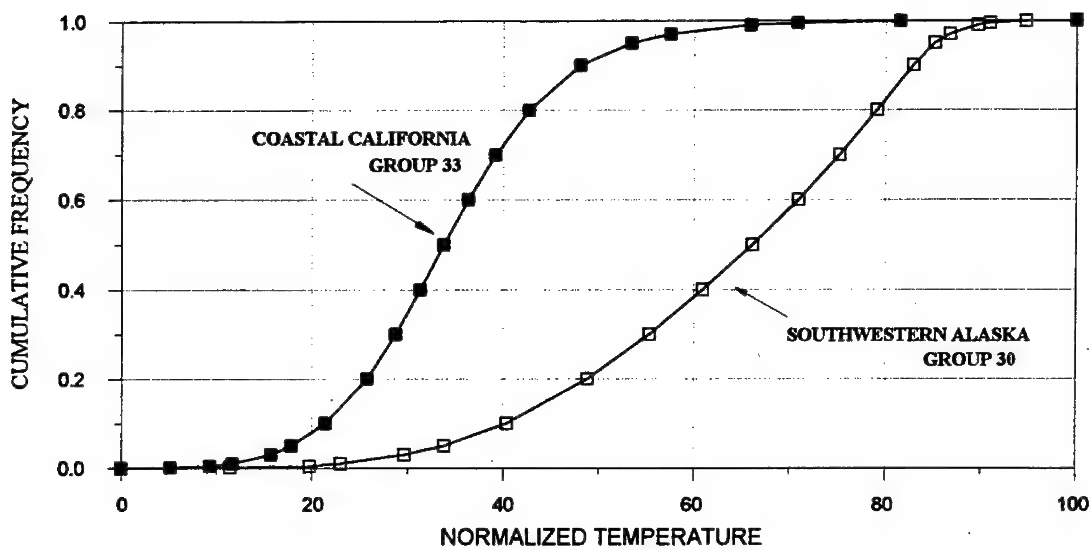

Figure 122. Outer Boundaries for Cumulative Frequency Curves: March

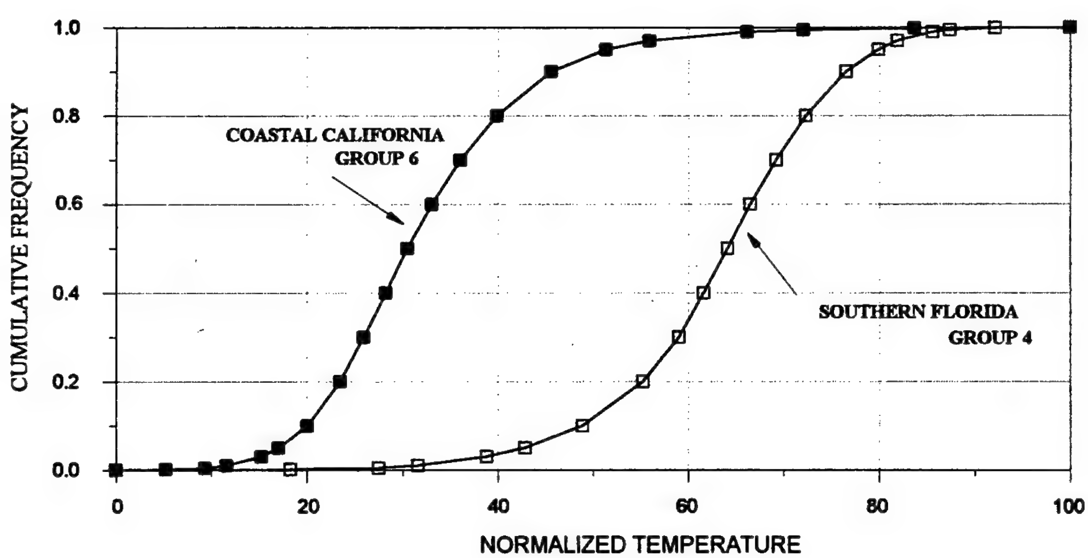

Figure 123. Outer Boundaries for Cumulative Frequency Curves: April

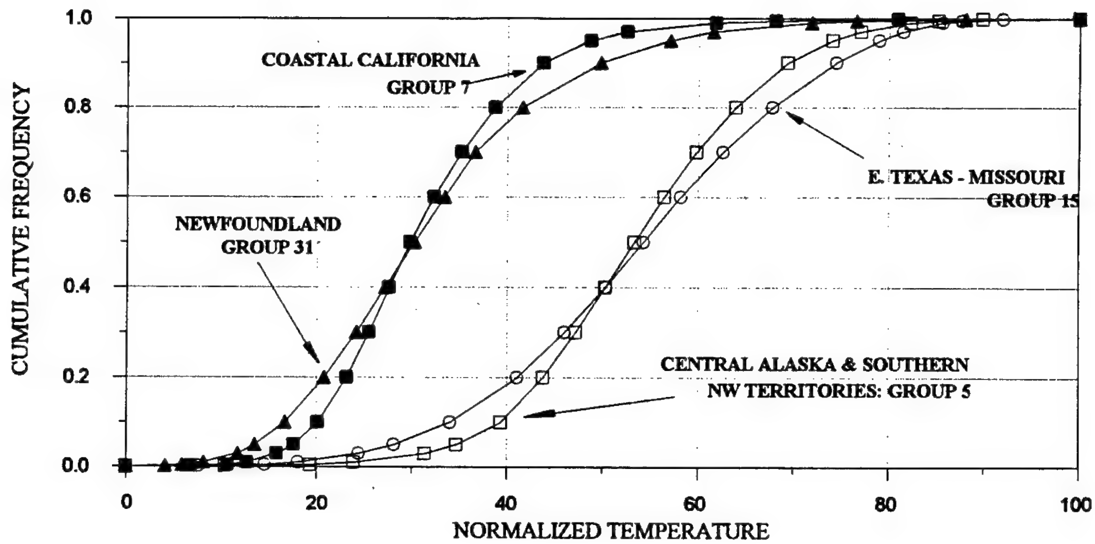

Figure 124. Outer Boundaries for Cumulative Frequency Curves: May

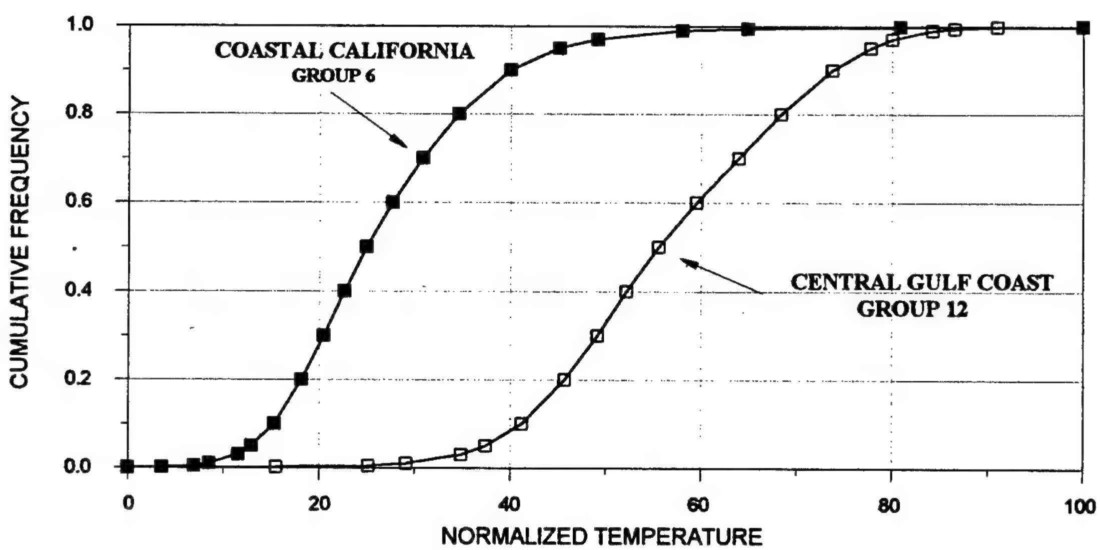

Figure 125. Outer Boundaries for Cumulative Frequency Curves: June

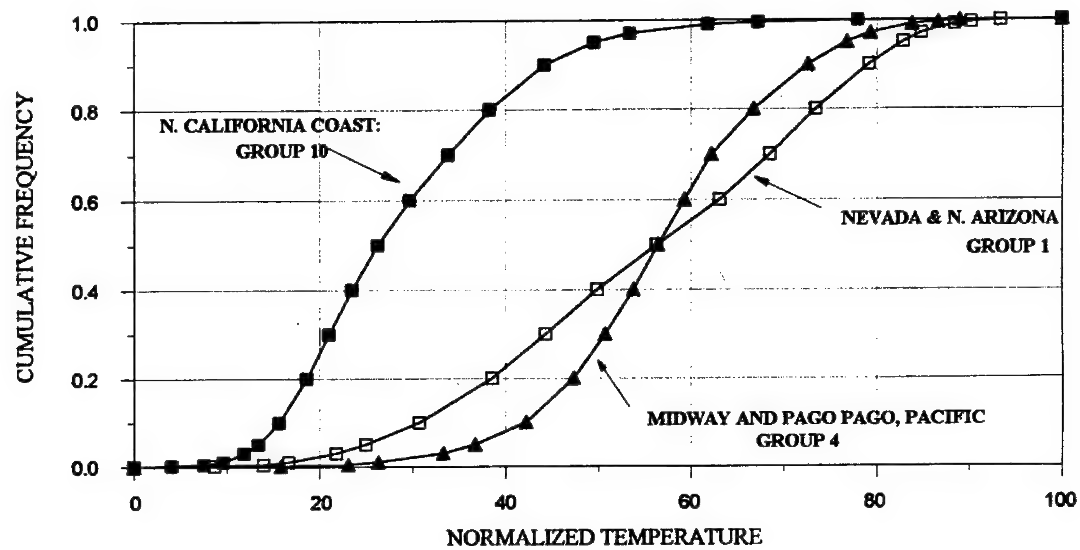

Figure 126. Outer Boundaries for Cumulative Frequency Curves: July

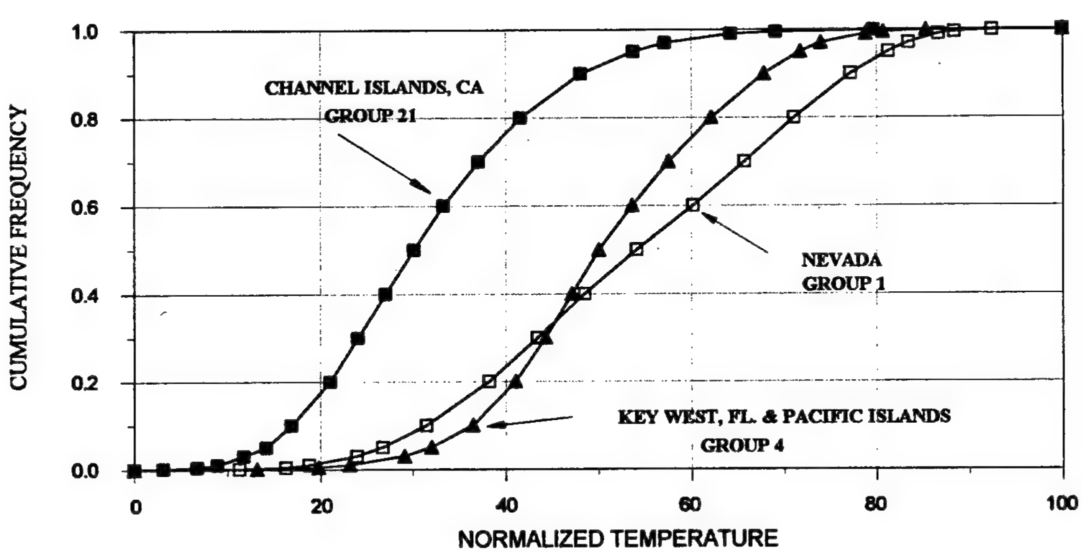

Figure 127. Outer Boundaries for Cumulative Frequency Curves: August

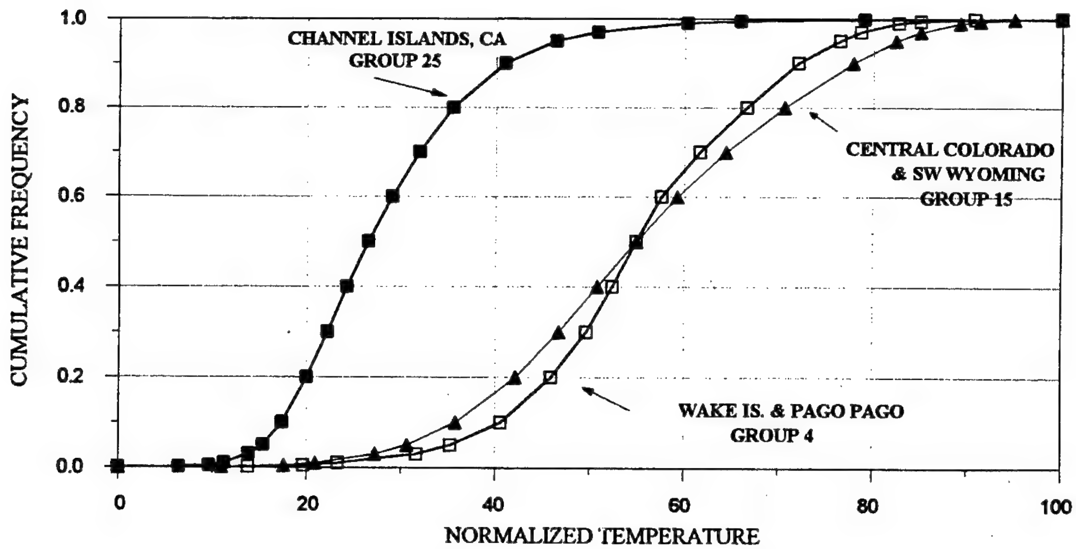

Figure 128. Outer Boundaries for Cumulative Frequency Curves: September

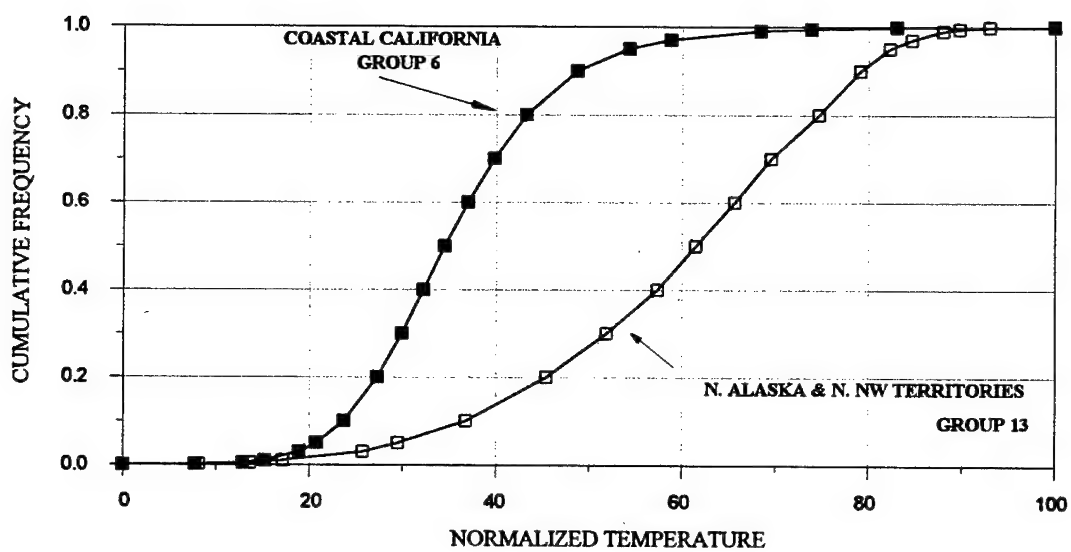

Figure 129. Outer Boundaries for Cumulative Frequency Curves: October

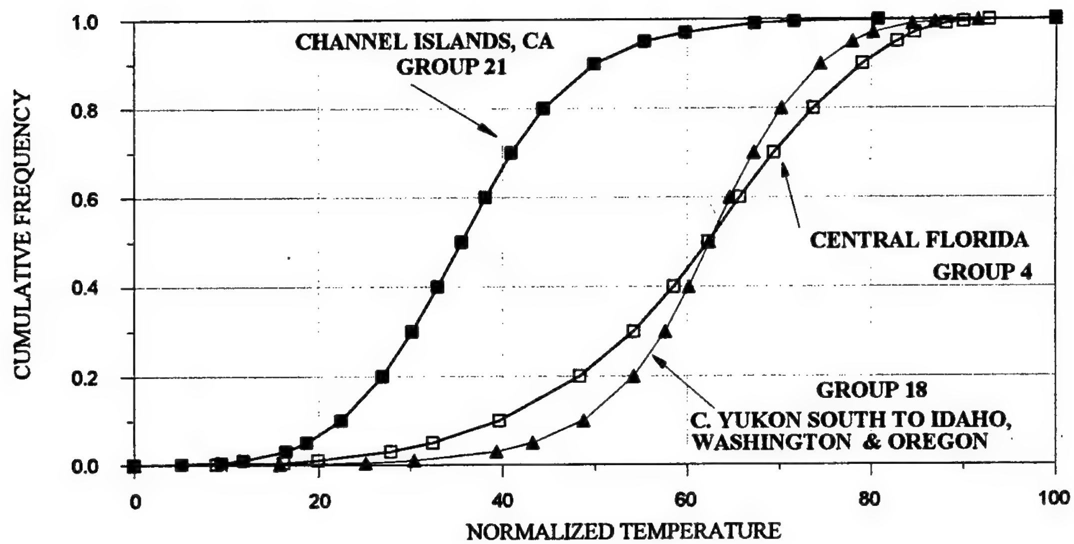

Figure 130. Outer Boundaries for Cumulative Frequency Curves: November

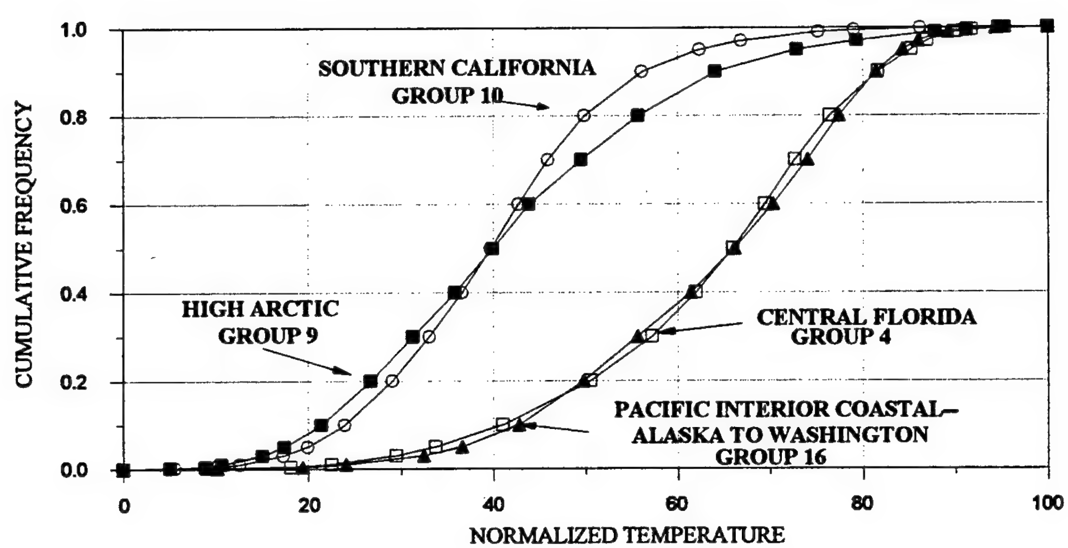

Figure 131. Outer Boundaries for Cumulative Frequency Curves: December

Table 72. Spans of Temperature (Normalized Degrees) by Frequency Level for Each Month

FREQ	MONTH												SUMMARY STATISTICS	
LEVEL	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVERAGE	STD DEV
0.001	14.13	9.81	12.24	15.94	12.28	12.92	13.04	10.14	12.50	7.93	12.87	12.19	12.16	2.08
0.005	23.32	15.79	13.61	20.80	14.44	18.61	17.39	21.42	19.97	11.02	18.89	15.19	17.54	3.62
0.01	24.92	18.40	14.72	21.90	15.74	20.65	18.91	22.23	21.32	13.82	22.13	16.49	19.27	3.48
0.03	27.27	24.79	18.41	23.99	19.70	23.32	24.61	24.76	22.76	15.51	25.85	18.84	22.48	3.55
0.05	28.09	27.34	20.19	25.82	21.16	24.46	25.36	24.79	23.20	15.43	26.48	20.71	23.59	3.64
0.1	29.32	29.80	22.15	28.89	22.63	25.90	27.53	25.46	25.32	17.87	26.37	21.90	25.26	3.56
0.2	29.81	31.80	24.75	31.77	23.00	27.50	28.76	25.13	28.65	19.16	27.30	24.61	26.85	3.71
0.3	28.93	32.53	27.12	33.05	23.46	28.61	29.82	24.64	29.99	21.98	27.41	26.43	27.83	3.39
0.4	27.70	31.98	29.55	33.37	24.00	29.56	30.38	24.64	30.88	25.10	27.20	26.11	28.37	3.04
0.5	29.11	30.87	32.31	33.57	24.73	30.56	30.20	25.25	31.57	26.93	27.25	26.31	29.05	2.90
0.6	27.00	29.02	34.62	33.44	25.91	31.83	33.37	26.93	32.49	28.64	27.61	27.62	29.87	3.06
0.7	24.47	26.54	36.04	33.09	27.38	33.11	34.65	28.67	33.84	29.74	28.46	28.14	30.34	3.67
0.8	23.66	24.53	36.45	32.39	29.21	33.76	35.14	29.53	35.43	31.38	29.29	27.58	30.69	4.16
0.9	23.37	22.17	34.88	30.95	30.65	34.09	35.30	29.12	36.91	30.36	29.11	25.57	30.21	4.71
0.95	20.76	20.01	31.73	28.78	30.55	33.78	34.70	27.44	35.98	28.01	27.33	22.89	28.50	5.25
0.97	18.63	18.72	29.23	27.16	29.60	32.78	33.21	26.51	34.17	25.87	24.90	20.11	26.74	5.45
0.99	16.23	16.60	23.75	21.43	24.92	28.83	27.77	25.35	28.90	23.32	20.80	15.55	22.79	4.77
0.995	14.91	14.10	20.86	17.62	21.10	24.06	23.91	23.19	25.42	24.51	18.36	14.01	20.17	4.25
0.999	14.96	9.89	13.89	11.77	13.12	13.44	15.52	18.71	15.88	21.52	13.64	11.01	14.45	3.24
MO. AVG.	23.50	22.88	25.08	26.62	22.82	26.72	27.34	24.42	27.64	22.00	24.28	21.12	24.54	3.76

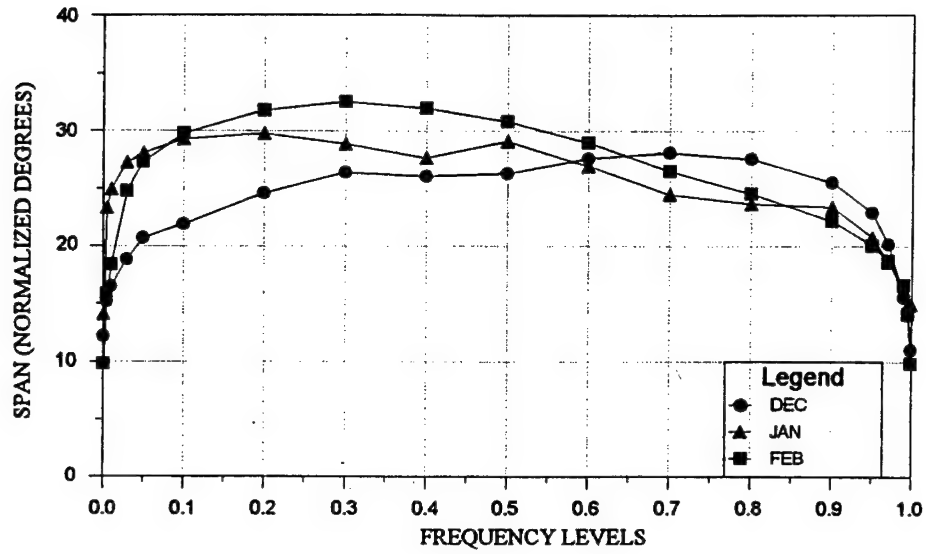

Figure 132. Span at Each Frequency Level: Winter Months

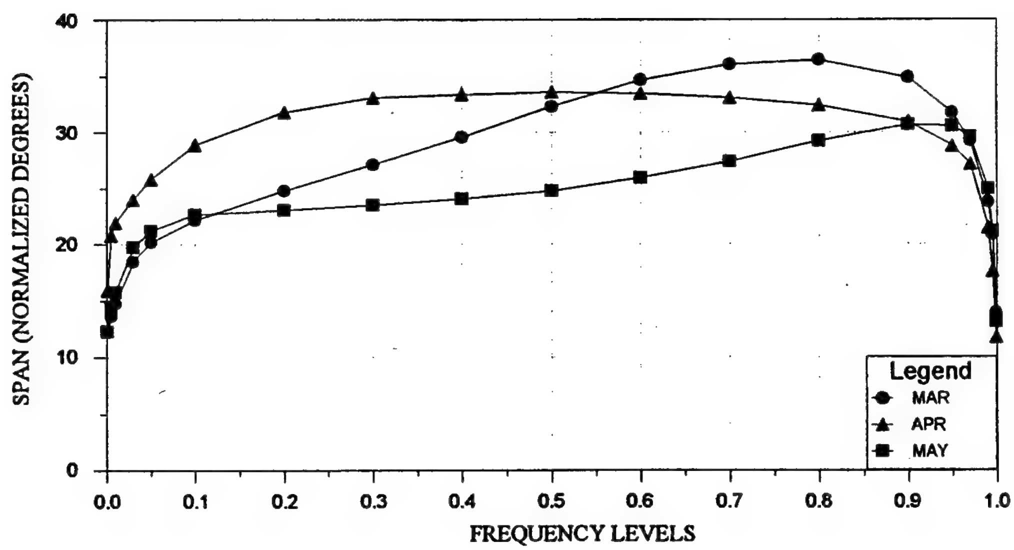

Figure 133. Span at Each Frequency Level: Spring Months

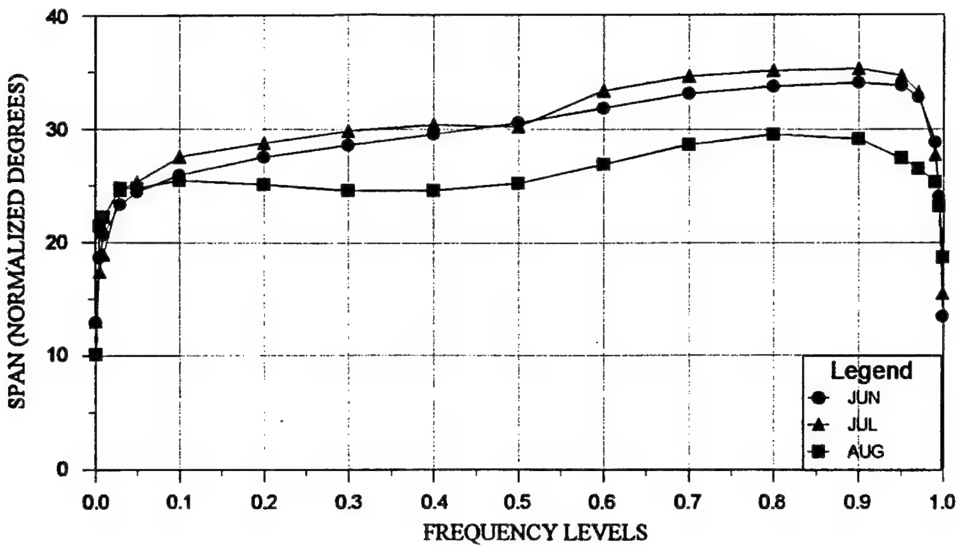

Figure 134. Span at Each Frequency Level: Summer Months

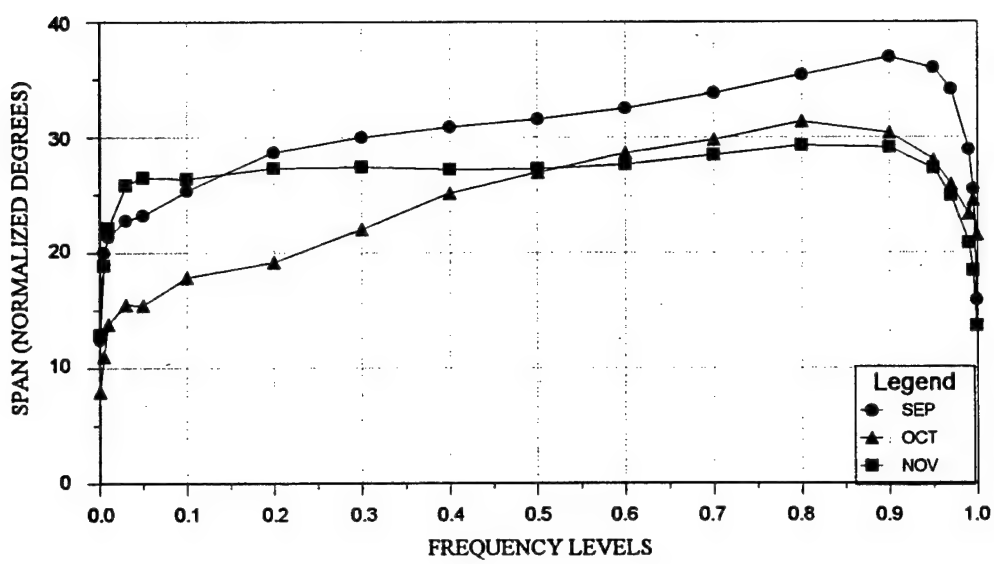

Figure 135. Span at Each Frequency Level: Autumn Months

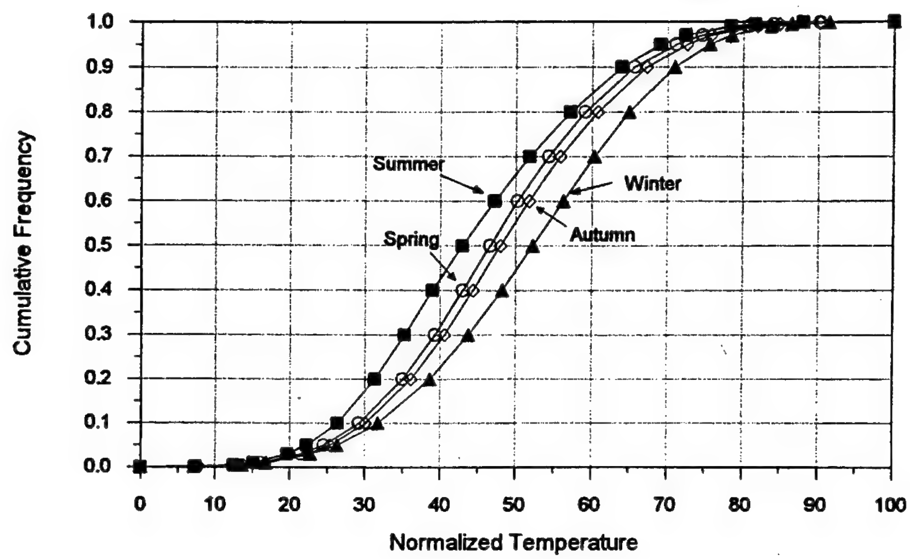

Figure 136. Composite Seasonal Curves

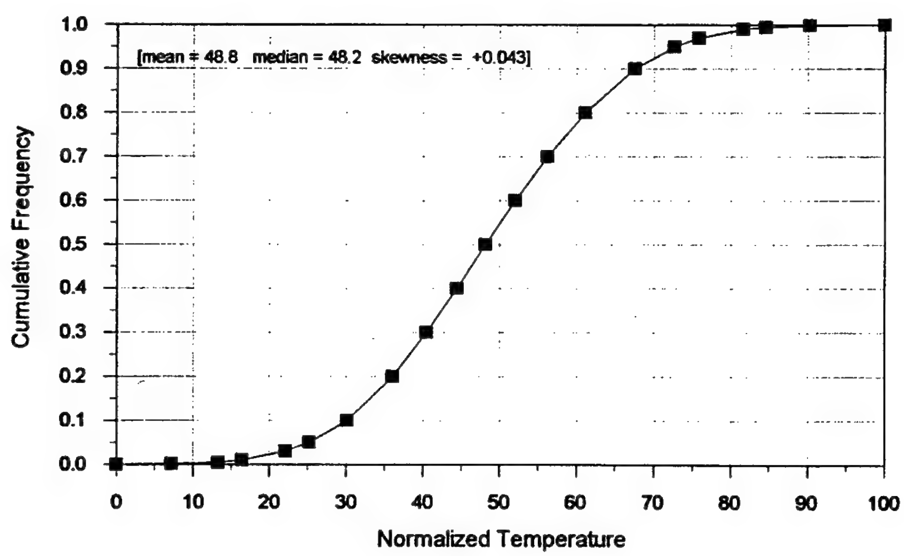

Figure 137. Composite Annual Temperature Frequency Curve

Testing the Model with Foreign Stations

As an additional test of the model performance, four stations outside of the study area were extracted from the ISMCS (NOCD, 1992). The stations were Kuwait International Airport, Paris (Orly Airport), Moscow and Capetown, South Africa. January and July were selected as the months for analysis. The stations were preprocessed to obtain the attribute variables and to generate the 19 standardized normalized temperatures. As Capetown is in the Southern Hemisphere, January data were used in the estimation of July's temperatures, and July's for the January estimation. Table 73 shows the results of this effort. Contained within the table is the January and July group to which the station was assigned, a geographic descriptor of the group, the number of residuals

Table 73. Test Runs of Model for Four Foreign Stations

Station	Assigned to Group	N.America Group Location	No. of Levels within +/-2.0 C	Maximum Residual (C)
Kuwait				
January	11	Yuma	19 of 19	1.3
July	16	Gulf Coast	9 of 19	2.9
Paris				
January	24	Puget Sound	16 of 19	2.6
July	22	Puget Sound	9 of 19	2.8
Moscow				
January	19	Montana	15 of 19	3.1
July	19	Central Canada	19 of 19	1.9
Capetown				
January	12	S.California	13 of 19	3.1
July	27	S.California	12 of 19	3.1

within the 2.0°C tolerance limits, and the maximum residual value (°C). In all cases, the group assignments appear relatively reasonable. The geographic areas to which these foreign stations were assigned appear to coincide quite well with their analogous North American counterparts. Accuracy ranges from average to excellent and, even when the number of correctly estimated levels is less than 50 percent, the maximum residuals are hovering only around 3.0°C. Although the model was developed from North American and Pacific island stations, it would appear that it has applicability to other areas of the world.

CONCLUSIONS

A methodology has been developed that allows the estimation of the frequency of occurrence of ambient air temperatures at locations for which only simple topographic and summarized climate information are available. The methodology uses discriminant analysis to assign a station to a particular group based on the station's topographic and climatic attribute data. Once assigned, a particular frequency of occurrence of any input temperature between the absolute maximum and absolute minimum can be estimated. The model, in essence, marries the graphical method used by Spreen and Lackey in the 1950s and 1960s in an effort to approximate temperature frequencies at any point along the cumulative frequency curve with various locational attribute variables that have been cited in previous research as contributors to the morphology of a location's temperature frequency distribution.

Overall, the model performed quite well, especially when considering the fact that only 198 model-building stations were used to define the temperature frequency curves for an area of over 6 million square miles. Annually, the model assigned stations to groups so that slightly over 92.5 percent of all generated temperatures (out of a total of 62,928) were within a ±2.0°C tolerance criterion measure. Elevation, latitude, Continentality and Precipitation Effectiveness (P/E) were the variables having the most discriminating power. The model, as a general rule, performed best: at the low to mid-latitude areas; at locations with low to moderate elevations; in regions with higher station density; and, during the warmer months of the year. Poorer model performance correlated well with: high latitude locations; high elevations; regions with low station density; and, the colder months of the year. The results closely mirror findings of past research on this subject that has taken place in the last 40+ years. For example, like this analysis, the models of Lackey (1960b), Spreen (1956), and Tattleman and Kantor (1977) also showed reduced accuracy at colder temperatures and at colder locations.

Although the number of groups required to maximize accuracy changed from month-to-month, the maps of these monthly temperature frequency groups showed patterns that, on a regional basis, varied quite consistently throughout the year. The monthly skewness maps provided an indication, in most cases, of dominance by certain large- and small-scale climatological and topographic features at different times of the year. Several examples would be the monthly persistence of highly positive skewness in California caused by dominance of the Pacific high and large shifts in skewness exhibited by the western coastal areas of North America in response to the advance and retreat of the Aleutian low. The presence of semi-permanent high pressure over the Great Basin during the colder months also is quite evident.

The attribute variables chosen as a basis for discriminating between the temperature frequency groups were chosen based on those appearing in previous research on the topic and also for their accessibility. The spatial patterns of the temperature frequency groups can, in most cases, be related closely to the patterns exhibited by the attribute variables. During the map analysis, however, it became quite apparent that other topographic/climatic variables were having an effect on the distribution of the temperature frequency groups. As previously discussed, the frequency of occurrence of air mass types appears to explain much of the groupings and the skewness patterns of the groups. This is quite apparent along the Pacific Coast of North America where both the Eastern Pacific low and the Aleutian low are affecting the area with greater or lesser magnitude throughout the year. The existence of the semi-permanent high over the U.S. Great Basin is quite apparent. Prevailing winds also were shown to affect the shapes of the group curves as well as to help determine their skewness. This is in line with the findings of Clark (1954) and Crow (1963). Proximity to bodies of water appears to have a major impact on group location and characteristics. The patterns in most coastal areas only varied minutely during the year, with the Gulf Coast, Peninsular Florida and the West Coast of the U.S. providing several examples.

Other attribute variables, not used in this model, can have an effect on the temperature frequency distribution of a location. In high elevations, slope, aspect and air drainage can be added to the elevation component. Local effects resulting from proximity to water bodies also are not considered. Likewise, there is no provision in the model for incorporating any measures of the urbanization effect ("Urban Heat Island") on the morphology of the temperature frequency curve. Therefore, it is safe to say, that other climatic variables, ranging from the micro- to macro-scale, can have definite impact on a station's thermal environment.

The density of stations also appears to have important implications in model results (especially in thermally diverse areas). The combined areas of Canada and Alaska, for example, cover slightly over 4.4 million mi^2 but contain only 31 stations in the entire data base -- a density of only 1 station for roughly every 142,000 mi^2. As previously shown, the thermal environment can be quite diverse over relatively small areas in cold, northern areas. Therefore, it's obvious that the model cannot hope to account for all this diversity. As another example, the work of Doeskin and McKee (1983) and Kunkel (1986) used a fairly high density of mountainous stations in relatively small geographic areas in their analysis. For this analysis, however, only about 20 stations were available for the extremely large areas of the U.S. Rocky Mountains and the Great Basin.

The application of the model to geographic areas outside of those used to create the model should be approached with caution. Although the results of the small applicability test with four stations appear quite encouraging, the extension of this model to other geographic regions must be tempered with the realization that a location may possess locally unique topographic and/or climatic attributes that are not represented in

the study area for which the models were developed.

In summation, the use of discriminant analysis with selected topographic/climatic attribute variables provides a robust methodology for discriminating between stations to permit the estimation of the frequency of occurrence of temperature. The monthly patterns of the temperature frequency groups can be largely explained by both the topographic and/or climatic variables used in the analysis. The density of stations, especially in such thermally diverse areas as mountains and high latitude locations, is a main factor in the model's somewhat lower performance in those areas. As in previous research, predictions during the colder months and at cold stations were poorer, primarily because of low station density and a great deal of thermal diversity that exists during these cold periods. In addition, other topographic and climatic variables (some continuous and others categorical), unaccounted for in the model itself, impact the nature of a location's temperature frequency curve. The addition of many of these variables, which were discussed previously, especially when analyzing smaller geographic areas, would no doubt improve the overall model results.

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APPENDIX A

Table 4. Model and Validation Stations

Station Number	Station Name	Latitude	Longitude	Elevation	Data Source	M= Model V=Validation
1	BIRMINGHAM, AL, US	33 34N	86 45W	620	NWS	M
2	HUNTSVILLE, AL, US	34 39N	86 46W	624	NWS	M
3	MOBILE, AL, US	30 41N	88 15W	211	NWS	M
4	MONTGOMERY, AL, US	32 18N	86 24W	221	NWS	M
5	ADAK (NAS), AK, US	51 53N	176 39W	13	USN	V
6	ANCHORAGE, AK, US	61 10N	150 01W	114	NWS	V
7	BARROW, AK, US	71 18N	156 47W	31	NWS	M
8	BETHEL, AK, US	60 47N	161 48W	125	NWS	M
9	FAIRBANKS, AK, US	64 49N	147 52W	436	NWS	M
10	KING SALMON, AK, US	58 41N	156 39W	49	NWS	M
11	KODIAK, AK, US	57 45N	152 30W	111	NWS	V
12	KOTZEBUE, AK, US	66 52N	162 38W	10	NWS	V
13	MC GRATH, AK, US	62 58N	155 37W	344	NWS	M
14	NOME, AK, US	64 30N	165 22W	13	NWS	V
15	YAKUTAT, AK, US	59 31N	139 40W	28	NWS	M
16	FORT SMITH, AR, US	35 20N	94 22W	449	NWS	V
17	LITTLE ROCK, AR, US	34 44N	92 14W	257	NWS	V
18	PHOENIX, AZ, US	33 26N	112 01W	1110	NWS	M
19	YUMA (MCAS), AZ, US	32 39N	114 36W	207	USN	M
20	TUCSON, AZ, US	32 08N	110 56W	2584	NWS	M
21	ALAMEDA (NAS), CA, US	37 47N	122 19W	13	USN	M
22	BAKERSFIELD, CA, US	35 25N	119 03W	495	NWS	M
23	CAMP PENDLETON, CA, US	33 18N	117 21W	75	USN	V
24	CHINA LAKE (NAF), CA, US	35 41N	117 41W	2283	USN	M
25	FRESNO, CA, US	36 46N	119 43W	100	NWS	V
26	LEMOORE (NAS), CA, US	36 20N	119 57W	236	USN	M
27	LONG BEACH, CA, US	33 49N	118 09W	66	NWS	M
28	LOS ANGELES, CA, US	33 56N	118 23W	100	NWS	M
29	MIRAMAR (NAS), CA, US	32 52N	117 09W	476	USN	V
30	MOFFETT FIELD (NAS), CA, US	37 25N	122 03W	39	USN	M
31	NORTH ISLAND (NAS), CA, US	32 42N	117 12W	26	USN	M
32	POINT MUGU (PMTC), CA,US	34 07N	119 07W	13	USN	M
33	SACRAMENTO, CA, US	38 31N	121 30W	18	NWS	M
34	SAN DIEGO, CA, US	32 44N	117 10W	13	NWS	M
35	SAN FRANCISCO, CA, US	37 37N	122 23W	8	NWS	M
36	COLORADO SPRINGS, CO, US	38 49N	104 43W	6090	NWS	M
37	DENVER, CO, US	39 46N	104 52W	5286	NWS	M
38	GRAND JUNCTION, CO, US	39 06N	108 33W	4849	NWS	M
39	HARTFORD, CT, US	41 56N	72 41W	160	NWS	V
40	WASH NATL, DC, US	38 51N	77 02W	10	NWS	V
41	WILMINGTON, DE, US	39 40N	75 36W	79	NWS	V
42	CECIL FIELD (NAS), FL, US	30 13N	81 53W	79	USN	V
43	DAYTONA BEACH, FL, US	29 11N	81 03W	29	NWS	M
44	FORT MYERS, FL, US	26 35N	81 52W	15	NWS	M

(Data Source: NWS = National Weather Service; USN = U.S. Navy)

Table 4. Model and Validation Stations (cont;)

Station Number	Station Name	Latitude	Longitude	Elevation	Data Source	M= Model V=Validation
45	JACKSONVILLE (NAS), FL, US	30 14N	81 40W	23	USN	M
47	KEY WEST NAS, FL, US	24 35N	81 41W	7	USN	V
48	KEY WEST, FL, US	24 33N	81 45W	4	NWS	M
50	MIAMI, FL, US	25 48N	80 18W	12	NWS	M
51	ORLANDO (MC COY), FL, US	28 26N	81 20W	91	NWS	M
53	PENSACOLA (NAS), FL, US	30 21N	87 19W	30	USN	M
54	TALLAHASSEE, FL, US	30 23N	84 22W	55	NWS	M
55	TAMPA, FL, US	27 58N	82 32W	19	NWS	M
56	W. PALM BEACH, FL, US	26 41N	80 07W	18	NWS	M
57	WHITING FIELD (NAS), FL, US	30 43N	87 01W	200	USN	M
58	ATHENS, GA, US	33 57N	83 19W	802	NWS	M
59	ATLANTA, GA, US	33 39N	84 26W	1010	NWS	M
60	AUGUSTA, GA, US	33 22N	81 58W	148	NWS	M
61	COLUMBUS, GA,US	32 31N	84 57W	449	NWS	V
62	MACON, GA, US	32 42N	83 39W	354	NWS	M
63	SAVANNAH, GA, US	32 08N	81 12W	46	NWS	V
64	MIDWAY ISLAND, HI, US	28 12N	177 23W	30	USN	M
65	LIHUE, HI, US	21 59N	159 21W	103	NWS	M
66	KANEOHE BAY (MCAS), HI, US	21 27N	157 47W	20	USN	M
67	BARBERS POINT (NAS), HI, US	21 19N	158 04W	33	USN	M
68	HONOLULU, HI, US	21 20N	157 55W	7	NWS	V
69	KAHULUI, HI, US	20 54N	156 26W	48	NWS	M
70	KOROR/PALAU ISLAND, PI	7 30N	134 29E	108	USN	V
71	TRUK ISLAND, PI	7 28N	151 51E	7	NWS	M
72	WAKE ISLAND, WK	19 17N	166 39E	12	NWS	M
73	SIOUX CITY, IA, US	42 24N	96 23W	1103	NWS	M
74	WATERLOO, IA, US	42 33N	92 24W	868	NWS	M
75	CHICAGO O'HARE, IL, US	41 59N	87 54W	674	NWS	V
76	DES MOINES, IA, US	41 32N	93 39W	938	NWS	V
77	GLENVIEW (NAS), IL, US	42 05N	87 50W	653	USN	V
78	MOLINE, IL, US	41 27N	90 30W	582	NWS	V
79	PEORIA, IL, US	40 40N	89 41W	650	NWS	V
80	ROCKFORD, IL, US	42 12N	89 06W	724	NWS	M
81	SPRINGFIELD, IL, US	39 51N	89 41W	594	NWS	M
82	EVANSVILLE, IN, US	38 03N	87 32W	380	NWS	M
83	FORT WAYNE, IN, US	41 00N	85 12W	797	NWS	V
84	INDIANAPOLIS, IN, US	39 44N	86 16W	792	NWS	M
85	SOUTH BEND, IN, US	41 42N	86 19W	773	NWS	M
86	CONCORDIA, KS, US	39 33N	97 39W	1470	NWS	M
87	DODGE CITY, KS, US	37 46N	99 58W	2582	NWS	M
88	GOODLAND, KS, US	39 22N	101 42W	3650	NWS	M
89	TOPEKA, KS, US	39 04N	95 38W	877	NWS	M
90	WICHITA, KS, US	37 39N	97 26W	1321	NWS	M
91	COVINGTON, KY, US	39 04N	84 40W	869	NWS	M

(Data Source: NWS = National Weather Service; USN = U.S. Navy)

Table 4. Model and Validation Stations (cont;)

Station Number	Station Name	Latitude	Longitude	Elevation	Data Source	M= Model V=Validation
92	LEXINGTON, KY, US	38 02N	84 36W	966	NWS	V
93	LOUISVILLE, KY, US	38 11N	85 44W	477	NWS	M
94	BATON ROUGE, LA, US	30 32N	91 08W	64	NWS	M
95	LAKE CHARLES, LA, US	30 07N	93 13W	9	NWS	M
96	NEW ORLEANS (NAS), LA, US	29 50N	90 01W	3	USN	M
97	NEW ORLEANS, LA, US	29 59N	90 15W	4	NWS	V
98	SHREVEPORT, LA, US	32 28N	93 49W	254	NWS	M
99	S. WEYMOUTH (NAS), MA, US	42 09N	70 56W	161	USN	M
100	BALTIMORE, MD, US	39 11N	76 40W	196	NWS	M
101	PATUXENT RIV. (NAS), MD, US	38 17N	76 25W	39	USN	V
102	PORTLAND, ME, US	43 39N	70 19W	57	NWS	M
103	ALPENA, MI, US	45 04N	83 34W	689	NWS	V
104	DETROIT METRO, MI, US	42 14N	83 20W	633	NWS	M
105	FLINT, MI, US	42 58N	83 45W	766	NWS	V
106	GRAND RAPIDS, MI, US	42 53N	85 31W	707	NWS	M
107	LANSING, MI., US	42 46N	84 36W	841	NWS	V
108	MUSKEGON, MI, US	43 10N	86 14W	628	NWS	M
109	SAULT STE MARIE, MI, US	46 28N	84 22W	724	NWS	M
110	DULUTH, MN, US	46 50N	92 11W	1428	NWS	V
111	INTERNL FALLS, MN, US	48 34N	93 23W	1179	NWS	M
112	MINN-ST PAUL, MN, US	44 53N	93 13W	834	NWS	V
113	ROCHESTER, MN, US	43 55N	92 30W	1297	NWS	M
114	COLUMBIA, MO, US	38 49N	92 13W	887	NWS	V
115	KANSAS CITY, MO, US	39 19N	94 43W	973	NWS	M
116	SPRINGFIELD, MO, US	37 14N	93 23W	1268	NWS	M
117	ST LOUIS, MO, US	38 45N	90 22W	535	NWS	M
118	GULFPORT, MS, US	30 24N	89 04W	30	USN	M
119	JACKSON, MS, US	32 19N	90 05W	330	NWS	V
120	MERIDIAN (NAS), MS, US	32 33N	88 34W	317	USN	M
121	MERIDIAN, MS, US	32 20N	88 45W	294	NWS	V
122	BILLINGS, MT, US	45 48N	108 32W	3567	NWS	M
123	GREAT FALLS, MT, US	47 29N	111 22W	3663	NWS	M
124	HELENA, MT, US	46 36N	112 00W	3893	NWS	M
125	KALISPELL, MT, US	48 18N	114 16W	2965	NWS	M
126	MILES CITY, MT, US	46 26N	105 52W	2628	NWS	M
127	MISSOULA, MT, US	46 55N	114 05W	3190	NWS	M
128	ASHEVILLE, NC, US	35 26N	82 33W	2140	NWS	M
129	CAPE HATTERAS, NC, US	35 16N	75 33W	11	NWS	V
130	CHARLOTTE, NC, US	35 13N	80 56W	700	NWS	V
131	CHERRY POINT, NC, US	34 54N	76 53W	30	USN	V
132	GREENSBORO, NC, US	36 05N	79 57W	886	NWS	M
133	NEW RIVER (MCAS), NC, US	34 43N	77 26W	26	USN	M
134	RALEIGH-DURHAM, NC, US	35 52N	78 47W	376	NWS	M
135	WILMINGTON,NC US	34 16N	77 54W	72	NWS	M

(Data Source: NWS = National Weather Service; USN = U.S. Navy)

Table 4. Model and Validation Stations (cont;)

Station Number	Station Name	Latitude	Longitude	Elevation	Data Source	M= Model V=Validation
136	BISMARCK, ND, US	46 46N	100 46W	1647	NWS	M
137	FARGO, ND, US	46 54N	96 48W	900	NWS	V
138	WILLISTON, ND, US	48 11N	103 38W	1899	NWS	M
139	GRAND ISLAND, NE, US	40 58N	98 19W	1841	NWS	M
140	LINCOLN, NE, US	40 51N	96 45W	1190	NWS	M
141	NORTH PLATTE,NE, US	41 08N	100 41W	2775	NWS	M
142	OMAHA, NE, US	41 18N	95 54W	980	NWS	M
143	SCOTTSBLUFF, NE, US	41 52N	103 36W	3945	NWS	M
144	VALENTINE, NE, US	42 52N	100 33W	2587	NWS	V
145	CONCORD, NH, US	43 12N	71 30W	346	NWS	M
146	ATLANTIC CITY. NJ, US	39 27N	74 34W	138	NWS	V
147	LAKEHURST (NAEC), NJ, US	40 02N	74 21W	102	USN	M
148	ALBUQUERQUE, NM, US	35 03N	106 37W	5326	NWS	M
149	ROSWELL, NM, US	33 18N	104 32W	3669	NWS	M
150	ELKO, NV, US	40 50N	115 47W	5075	NWS	M
151	ELY, NV, US	39 17N	114 51W	6262	NWS	V
152	FALLON (NAS), NV, US	39 25N	118 43W	3933	USN	M
153	LAS VEGAS, NV, US	36 05N	115 10W	2162	NWS	M
154	RENO, NV, US	39 30N	119 47W	4404	NWS	M
155	WINNEMUCCA, NV, US	40 54N	117 48W	4297	NWS	M
156	ALBANY, NY, US	42 45N	73 48W	275	NWS	M
157	BINGHAMTON, NY, US	42 13N	75 59W	1600	NWS	V
158	BUFFALO, NY, US	42 56N	78 44W	705	NWS	M
159	N Y KENNEDY, NY, US	40 39N	73 47W	16	NWS	V
160	N Y LA GUARDIA, NY, US	40 46N	73 54W	11	NWS	M
161	ROCHESTER, NY, US	43 07N	77 40W	547	NWS	M
162	SYRACUSE, NY, US	43 07N	76 07W	421	NWS	M
163	AKRON-CANTON, OH, US	40 55N	81 26W	1208	NWS	V
164	CLEVELAND, OH, US	41 25N	81 52W	770	NWS	M
165	COLUMBUS WSO, OH, US	40 00N	82 53W	812	NWS	M
166	DAYTON, OH, US	39 54N	84 12W	995	NWS	M
167	TOLEDO EXPRESS, OH, US	41 35N	83 48W	669	NWS	M
168	YOUNGSTOWN, OH, US	41 15N	80 40W	1178	NWS	M
169	OKLAHOMA CITY, OK, US	35 24N	97 36W	1280	NWS	V
170	TULSA, OK, US	36 11N	95 54W	668	NWS	M
171	ASTORIA, OR, US	46 09N	123 53W	8	NWS	M
172	MEDFORD, OR, US	42 23N	122 53W	1300	NWS	M
173	PORTLAND, OR, US	45 36N	122 36W	21	NWS	V
174	SALEM, OR, US	44 55N	123 01W	195	NWS	M
175	ALLENTOWN, PA, US	40 39N	75 26W	388	NWS	M
176	ERIE, PA, US	42 05N	80 11W	732	NWS	V
177	HARRISBURG, PA, US	40 13N	76 51W	338	NWS	M
178	PHILADELPHIA, PA, US	39 53N	75 14W	10	NWS	M
179	PITTSBURGH, PA, US	40 30N	80 13W	1150	NWS	V

(Data Source: NWS = National Weather Service; USN = U.S. Navy)

Table 4. Model and Validation Stations (cont;)

Station Number	Station Name	Latitude	Longitude	Elevation	Data Source	M= Model V=Validation
180	WIL-BARE-SCRANTON, PA, US	41 20N	75 44W	930	NWS	M
181	WILLIAMSPORT, PA, US	41 15N	76 55W	524	NWS	M
182	WILLOW GROVE (NAS), PA, US	40 12N	75 09W	361	USN	M
183	PROVIDENCE, RI, US	41 44N	71 26W	51	NWS	M
184	BEAUFORT (MCAS), SC, US	32 29N	80 43W	38	USN	M
185	CHARLESTON, SC, US	32 54N	80 02W	41	NWS	M
186	COLUMBIA, SC, US	33 57N	81 07W	213	NWS	M
187	GRNVLE-SPARTBG, SC, US	34 54N	82 13W	973	NWS	M
188	RAPID CITY, SD, US	44 03N	103 04W	3162	NWS	M
189	SIOUX FALLS, SD, US	43 34N	96 44W	1418	NWS	M
190	BRISTOL, TN, US	36 29N	82 24W	1525	NWS	M
191	CHATTANOOGA, TN, US	35 02N	85 12W	692	NWS	V
192	KNOXVILLE, TN, US	35 48N	84 00W	949	NWS	V
193	MEMPHIS, TN, US	35 03N	90 00W	265	NWS	M
195	NASHVILLE, TN, US	36 07N	86 41W	580	NWS	V
196	ABILENE, TX, US	32 25N	99 41W	1784	NWS	V
197	AMARILLO, TX, US	35 14N	101 42W	3590	NWS	V
198	BROWNSVILLE, TX, US	25 54N	97 26W	19	NWS	V
199	CHASE FIELD (NAS), TX, US	28 22N	97 40W	190	USN	M
200	CORPUS CHRISTI (NAS), TX, US	27 42N	97 17W	20	USN	V
201	CORPUS CHRISTI, TX, US	27 46N	97 30W	44	NWS	M
202	DALLAS-FT. WORTH, TX, US	32 54N	97 02W	551	NWS	V
203	DALLAS (NAS), TX, US	32 44N	96 58W	495	USN	M
204	EL PASO, TX, US	31 48N	106 24W	3918	NWS	M
205	HOUSTON, TX, US	29 58N	95 21W	96	NWS	V
206	KINGSVILLE (NAS), TX, US	27 30N	97 49W	49	USN	M
207	LUBBOCK, TX, US	33 39N	101 49W	3254	NWS	M
208	MIDLAND/ODESSA, TX, US	31 57N	102 11W	2857	NWS	M
209	PORT ARTHUR, TX, US	29 57N	94 01W	16	NWS	M
210	SAN ANGELO, TX, US	31 22N	100 30W	1903	NWS	M
211	SAN ANTONIO, TX, US	29 32N	98 28W	794	NWS	V
212	VICTORIA, TX, US	28 51N	96 55W	104	NWS	M
213	WACO, TX, US	31 37N	97 13W	500	NWS	M
214	WICHITA FALLS, TX, US	33 58N	98 29W	994	NWS	V
215	SALT LAKE CITY, UT, US	40 47N	111 57W	4222	NWS	M
216	NORFOLK (NAS), VA, US	36 56N	76 17W	16	USN	V
217	NORFOLK, VA, US	36 54N	76 12W	22	NWS	M
218	OCEANA (NAS), VA, US	36 49N	76 02W	20	USN	M
219	QUANTICO (MCAF), VA, US	38 30N	77 19W	13	USN	M
220	RICHMOND, VA, US	37 30N	77 20W	164	NWS	M
221	ROANOKE, VA, US	37 19N	79 58W	1149	NWS	M
222	WASH DULLES, VA, US	38 57N	77 27W	29	NWS	V
223	BURLINGTON, VT, US	44 28N	73 09W	332	NWS	M
224	OLYMPIA, WA, US	46 58N	122 54W	192	NWS	V

(Data Source: NWS = National Weather Service; USN = U.S. Navy)

Table 4. Model and Validation Stations (cont;)

Station Number	Station Name	Latitude	Longitude	Elevation	Data Source	M= Model V=Validation
225	QUILLAYUTE, WA, US	47 57N	124 33W	179	NWS	M
226	SEATTLE-TACOMA, WA, US	47 27N	122 18W	450	NWS	V
227	SPOKANE, WA, US	47 38N	117 32W	2356	NWS	M
228	WHIDBEY ISL. (NAS), WA, US	48 21N	122 40W	46	USN	M
229	YAKIMA, WA, US	46 34N	120 32W	1064	NWS	M
230	GREEN BAY, WI, US	44 29N	88 08W	682	NWS	M
231	MADISON, WI, US	43 08N	89 20W	858	NWS	M
232	MILWAUKEE, WI, US	42 57N	87 54W	672	NWS	V
233	BECKLEY, WV, US	37 47N	81 07W	2504	NWS	V
234	CHARLESTON, WV, US	38 22N	81 36W	1015	NWS	M
235	HUNTINGTON, WV, US	38 22N	82 33W	827	NWS	M
236	CASPER, WY, US	42 55N	106 28W	5338	NWS	V
237	CHEYENNE, WY, US	41 09N	104 49W	6120	NWS	M
238	LANDER, WY, US	42 49N	108 44W	5370	NWS	M
239	SHERIDAN, WY, US	44 46N	106 58W	3964	NWS	V
240	HILO, HI, US	19 43N	155 04W	36	NWS	V
241	GUANTANAMO BAY (NAS), CU	19 54N	75 13W	56	USN	M
242	SAN JUAN, PU	18 26N	66 00W	9	NWS	V
243	CALGARY, CN	51 06N	114 01W	3556	USN	M
244	EDMONTON, CN	53 18N	113 35W	2371	USN	M
245	HALIFAX, CN	44 53N	63 31W	476	USN	V
246	MONTREAL, CN	45 28N	73 45W	118	USN	M
247	OTTAWA, CN	45 19N	75 40W	374	USN	M
248	QUEBEC, CN	46 48N	71 23W	239	USN	V
249	SAINT JOHN, CN	45 19N	65 53W	358	USN	M
250	TORONTO, CN	43 40N	79 38W	567	USN	M
251	VANCOUVER, CN	49 11N	123 10W	7	USN	M
252	VICTORIA , CN	48 39N	123 26W	62	USN	M
253	WINNIPEG, CN	49 54N	97 14W	784	USN	M
254	GANDER, CN	48 57N	54 34W	495	USN	M
255	GOOSE BAY, CN	53 19N	60 25W	144	USN	M
256	ST. JOHNS, CN	47 37N	52 44W	459	USN	M
257	SIDNEY, CN	46 10N	60 03W	203	USN	M
258	CAPE DYER, CN	66 35N	61 37W	1289	USN	M
259	FROBISHER, CN	63 45N	68 32W	112	USN	M
260	ANGMAGSSALIK,GL	65 36N	37 38W	171	USN	M
261	DANMARKSHAVN, GL	76 46N	18 40W	0	USN	V
262	GODTHAB, GL	64 10N	51 45W	157	USN	M
263	JULIANEHAB, GL	60 43N	46 03W	112	USN	M
264	NORD, GL	81 36N	16 40W	0	USN	M
265	SONDER STROMFJORD, GL	67 00N	50 48W	174	USN	M
266	THULE, GL	76 32N	68 45W	0	USN	M
267	SABLE ISLAND, CN	43 56N	60 01W	13	USN	M
268	SHEARWATER, CN	44 38N	63 30W	167	USN	M

(Data Source: NWS = National Weather Service; USN = U.S. Navy)

Table 4. Model and Validation Stations (cont;)

Station Number	Station Name	Latitude	Longitude	Elevation	Data Source	M= Model V=Validation
269	YARMOUTH, CN	43 50N	66 05W	134	USN	M
270	SAN NICHOLAS IS., CA, US	33 14N	119 28W	504	USN	V
271	SAN CLEMENTE, CA, US	33 00N	118 35W	168	USN	M
272	POCATELLO, ID, US	42 55N	112 36W	4454	NWS	M
273	BOISE, ID, US	43 34N	116 13W	2838	NWS	V
274	BRUNSWICK (NAS), ME, US	43 54N	69 56W	75	USN	V
275	AGANA (NAS), MY	13 29N	144 48E	246	USN	M
276	KWAJALEIN MISL. RGN, MH	8 44N	167 44E	7	NWS	M
277	MAJURO, MH	7 05N	171 23E	10	NWS	V
278	YAP, KA	9 29N	138 05E	44	NWS	M
279	PAGO PAGO, AMER. SAMOA	14 20S	170 43W	10	NWS	M

(Data Source: NWS = National Weather Service; USN = U.S. Navy)

Table 5. Canadian Second-Order Stations

Station Number	Station Name	Latitude	Longitude	Elevation	Data Source
1	PAGWA	50 02N	85 16W	620	WWAS
2	EMBARRAS	58 12N	111 23W	775	WWAS
3	WAGNER	55 21N	114 59W	1915	WWAS
4	SMITH RIVER	59 54N	126 26W	2204	WWAS
5	COPPERMINE	67 49N	115 05W	28	WWAS
6	NORMAN WELLS	65 17N	126 48W	239	WWAS
7	SNAG	62 22N	140 24W	1913	WWAS
8	ISACHSEN	78 47N	103 32W	175	WWAS
9	GILLIAM	56 35N	94 42W	454	WWAS
10	NITCHEQUON	53 12N	70 54W	1690	WWAS
11	BROCHET	57 54N	101 40W	1150	WWAS
12	VALD'OR	48 03N	77 47W	1106	WWAS
13	PRINCE ALBERT	53 12N	105 41W	1405	WWAS
14	CORAL HARBOR	64 11N	83 21W	210	WWAS
15	YELLOWKNIFE	62 28N	114 27W	674	WWAS
16	FORT CHIMO	58 06N	68 26W	105	WWAS
17	SEPT ISLES	50 13N	66 16W	180	WWAS
18	TROUT LAKE	53 50N	89 52W	720	WWAS
19	CHESTERFIELD	53 20N	90 43W	13	WWAS
20	PRINCE GEORGE	53 53N	122 41W	2268	WWAS
21	KAMLOOPS	50 42N	120 10W	1134	WWAS

(WWAS = World Wide Airfield Summaries, U.S. Navy)